THE TREATMENT OF TEETH

NOTES ON THE TREATMENT AND FILLING OF TEETH

BY

WM. CASS GRAYSTON, L.D.S.

SECOND EDITION

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PREFACE

TO THE SECOND EDITION

A SECOND edition of these "Notes" having been called for, it has been found necessary to considerably revise and enlarge them in order to keep pace with the march of dental progress.

The scheme of the first edition is adhered to, inasmuch as no attempt is made to write a complete treatise on "The Treatment and Filling of Teeth," but merely to allude to certain points in operative dentistry which have particularly interested the writer.

It would perhaps be better if the title were "Notes on the Filling and Treatment of Teeth," but the original title (which was chosen because the treatment of a diseased tooth comes before the filling) is retained to avoid confusion.

The word occlusal is selected in preference to the more usual term crown, whenever the masticating surface of a bicuspid or molar is indicated, for the word crown really includes the whole of the exposed surfaces, viz., mesial, distal, buccal, and lingual, as well as masticating or occlusal.

WM. CASS GRAYSTON.

February 1904.

INTRODUCTION

TO THE FIRST EDITION

It is not intended in the following notes to enter exhaustively into the subject of treating and filling teeth, but merely to allude to certain practical points in a simple manner. The scientific principles which underlie all practical work are not dealt with, for they are best studied in the works of those who have devoted much time to scientific research. It has been frequently stated, and is very true, that success in any operation depends more on the man who performs it than on the method he employs, and consequently a description of personal work, in which there is little, if anything, that is new or original may be of small interest to the experienced. It is hoped, however, that here and there may be found a hint that will be of service to younger practitioners.

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NOTES ON THE TREATMENT AND FILLING OF TEETH

CHAPTER I

THE RELIEF OF PAIN

As many patients consult a dentist primarily for the relief of toothache, it will be well to briefly consider the usual causes of this most distressing pain, and the remedies which generally relieve it.

Toothache is most frequently caused by irritation and inflammation of the tooth-pulp, by irritation and inflammation of the dental periosteum, or by a combined inflammation of both these parts. In the various text-books accurate and careful descriptions of the pain caused by these different conditions, and also by the various stages of the same condition, are clearly set forth; but it happens in practice that few patients are capable of accurately describing the pain they have suffered, and beyond making a few general inquiries, such as how long the pain has

existed, whether or no it keeps them awake at night, and whether it is very severe, the questioning of patients is of very little value, and the diagnosis must always principally depend on the eyes and instruments of the operator. If the tooth to which the patient refers the pain is carious, the decay should be removed sufficiently to admit a temporary filling. If the pulp is not exposed, and external pressure on the tooth in all directions gives no pain, if there is no tenderness on applying pressure to the gum over the roots of the tooth, and if the pain has not been severe, it may be presumed the cause is pulp irritation, and that the case will be readily amenable to treatment. Any of the usual remedies, such as carbolic acid, oil of cloves, or creosote, will generally give prompt relief. A very useful preparation is a paste made of carbolic acid, oil of cloves, and tannin, to which, in all cases of severe pain caused by an inflamed pulp, a little cocaine may be added with advantage. Whenever this paste is allowed to remain in a tooth for from twenty-four hours to a few days, it will be found that the tannin has dried up and hardened the softened dentine; this renders its removal easier and less painful, and frequently does away with the necessity for flooring a cavity with cement or gutta-percha in order to prevent shocks from thermal

change. It is important to relieve pain as promptly as possible, and in order to effect this it is occasionally necessary in cases of non-exposure of the pulp, to apply the rubber dam and thoroughly dry the dentine with applications of absolute alcohol and warm air, in order to promote the absorption of the medicament. It is hardly necessary to mention that if one remedy does not answer, another one should be tried. It will often be found that an alternate application of two or three remedies is better than a continuous application of a single one. It is also hardly necessary to say, that whenever the pain is severe, every effort should be made to relieve it before the patient leaves the chair, and that it is frequently advisable, if the pain has not completely subsided, to tell the patient to return in from half-an-hour to an hour, if necessary. An application of chloroform may "act as a charm" in quickly relieving pain; but it should always be followed by one of the above-mentioned, or some equally useful medicament, owing to its effects rapidly "passing off."

Whenever an aching tooth, with a live but unexposed pulp, resists the usual treatment, it generally becomes a question, whether the pulp shall be boldly opened into, so as to enable the remedies to be placed in direct contact with it; whether arsenical paste shall be at once applied, informing the patient

that probably severe pain will ensue for some hours; or whether the tooth shall be extracted. The position of the cavity, the value of the tooth, and the temperament of the patient, are all factors in determining the line of treatment. If, on removing the loose débris from the cavity, a portion of the pulp is seen to be exposed, it is well to remove as much of the softened dentine in the neighbourhood of the exposure as can be done without causing pain. An application of one or more of the above-mentioned remedies will usually stop the pain. Whatever application or dressing is used must always be carefully sealed in the cavity before the patient is dismissed; and it is important to do this with as little pressure as possible. Pressure not only causes pain in these cases, but may also force out the greater part of the medicament on which so much depends. Temporary gutta-percha, thinly mixed phosphate cement, Fletcher's artificial dentine, and cotton-wool saturated with fairly thick mastic or sandarach varnish, are all efficient temporary fillings or dressing seals. Whichever is selected in any particular case will depend on the judgment of the operator. If there is an opening into the pulp chamber, and any doubt exists as to whether the pulp is alive, or partially or wholly dead, a very fine Donaldson bristle with a sharp point should be delicately inserted.

If care is used, and the pulp is alive, the patient will only feel a slight prick, not amounting to pain. Should the insertion of the bristle cause no sensation, the pulp-chamber should be freely opened, and explorations made down the root-canals. In inserting the bristle into a root-canal one is occasionally deceived, for even slight pressure may cause the patient to wince, and the operator to conclude he has pricked into living pulp, when the real cause of the pain is the pressure conveyed to an inflamed peridental membrane. It is astonishing how little pressure, even with such a delicate instrument as a Donaldson bristle, will sometimes cause a patient to tell the operator he has "touched the nerve," subsequent examination revealing that the pulp is entirely dead.

Periosteal inflammation, caused by an inflamed pulp, is readily relieved by soothing the pulp with any appropriate remedy. The treatment of a tooth with a highly inflamed peridental membrane is often rendered extremely difficult, and sometimes impossible, owing to the slightest pressure produced by manipulation causing such pain that the patient will not submit to it.

Inflammation of the alveolar periosteum, or dental periosteum, or peridental membrane, as it is variously termed, is generally caused by septic

poison from a dead pulp. The pain is usually relieved by freely opening the pulp-chamber—thus giving vent to the foul gases of decomposition—and by the application of counter irritants to the gum, iodine liniment being very useful for this purpose. Capsicum plasters are also very good, the difficulty being for patients to make them stay in place sufficiently long to be of service.

When peridental inflammation has reached the suppurative stage, very little relief will be obtained until the pus is able to escape. In many cases the fine steel bristle may be passed through the apex of the root, and the pus will at once flow down through the root-canal. In other cases the patient may be directed to poultice the gum with pieces of hot figs, or to apply the more convenient capsicum plasters until the pus is drawn through the alveolus into the gum, whence it is readily evacuated with a lancet. Drilling through gum and alveolus gives speedy relief in many cases, but is too heroic a method for general practice.

Whenever the patient resists the manipulation necessary to vent the canals, it becomes a question of the judgment of the operator, whether he will attempt to get rid of the pain by trusting solely to local applications to the gum, or whether he will at once extract the tooth. An excellent method in

these cases, where the cavity of decay is very accessible, and also in cases of obstinate pulp inflammation without exposure, is to administer gas and freely open up the pulp-chamber with a large clean bur in the dental engine. After opening into a septic tooth and exposing the orifices of the root-canals, it is advisable to postpone further manipulation until the pain has subsided; and in these cases the cavity should be left open, merely filling it loosely with cotton-wool to prevent it becoming choked up with food. If a dead pulp is in a sufficiently coherent state to be readily removed, it should usually be taken out of the tooth at once. In all cases of obstinate toothache, no matter what may be the cause, the application of strong tincture of iodine (iodine liniment) to the gum is useful. Another valuable application is: Alcohol, 1 oz.; chloroform, 2 oz.; ether, ¾ oz.; gum camphor, ½ oz.; laudanum, ⅛ oz.; oil of cloves, ½ dr. To apply this mixture, saturate a fairly large pellet of cotton-wool, and hold it on the gum for a few minutes, taking care to prevent the liquid running on to the face, as it is apt to irritate and burn the skin.

The diagnosis of toothache is often difficult. Frequently the pain is referred by the patient to a tooth that is perfectly sound. An examination of all the teeth in both jaws should be made, and if,

as is usually the case, one or more decayed teeth are found on the same side of the face as the tooth to which the pain is referred, the treatment of one or more of these teeth will give relief. Pain caused by one decayed tooth may be referred to any other tooth in either jaw on the same side of the face as the affected tooth, but it is extremely rare for it to pass the median line; thus the writer has known pain caused by a left lower wisdom tooth to be felt in a left upper central incisor, but has never known a tooth on the left side (either upper or lower) to cause pain on the right side, and *vice versâ*. Frequently the pain is referred to one of the branches of the fifth nerve, and is then termed neuralgia. The pain is usually felt under or over the eye; in the temporal region; in and under and in front of the ear; running upwards to the temporal region, or downwards to the shoulder and arm.

Pain under or over the eye usually points to upper teeth being affected; while pain in or about the ear, particularly if the pain is at the back of the ear, or shoots downwards, points to lower teeth; "while pain over the parietal eminence, to trouble from either upper or lower teeth."[1]

In these cases the condition of the decayed teeth

[1] Smale and Colyer.

must be ascertained, and suitable remedies applied, when the neuralgic pain will usually cease.

In cases where several teeth have been filled, and the patient cannot locate the pain in any one tooth in particular, the diagnosis is again often difficult. Tenderness of a tooth to pressure, or tenderness of the gum over any particular tooth, or looseness of a tooth, is sufficient evidence for the removal of a filling.

In other cases the application of heat and cold must be resorted to. To apply heat, make a ball-ended steel burnisher, or the copper bulb of the Evans' root-drier, very hot—or the hot-air syringe may be used; while cold is conveniently applied by holding a small ball of cotton-wool in the foil carriers, spraying chloride of ethyl on to it until it is covered with particles of ice, and then rapidly applying it. If all the filled teeth are separately tested in this way, one or other of them will usually prove either more or less sensitive than the rest, and the filling of this tooth should be removed, and the conditions ascertained and treated.

Tapping the teeth with the handle of a steel instrument is also useful; sometimes a tooth will prove more tender than the others if tested in this manner, and this is often a useful guide.

The above methods of diagnosis apply to cases

where none of the teeth are carious, with the exception that if any one tooth responds to the test, it must be drilled into through the sound structure. Before drilling into a tooth that is externally sound, great care must be taken; and if any doubt exists it is better for the patient to wait to see if the pain will finally locate itself in one particular tooth, or symptoms develop which enable a more accurate diagnosis to be made. If an apparently sound tooth is less translucent, or darker in colour than its fellows, it will generally be found to contain a dead pulp, and it may be opened into in these cases without any hesitation.

The electric mouth mirror will be of assistance in some of these cases. The room should be darkened and the light placed behind the teeth. A want of translucency, which is not apparent in daylight, may then be discovered.

Severe toothache, which is often of the referred or reflected kind, is frequently caused by the difficult eruption of a wisdom tooth, particularly a lower wisdom. This possible factor must always be considered. The treatment is to cut away the gum over the erupting tooth, and cauterise the edges with nitrate of silver. If this does not relieve the pain, the wisdom tooth must be extracted. And if this is an uncertain or risky operation, the tooth

immediately in front should be sacrificed. This gives room for the wisdom tooth to erupt, and by thus relieving pressure the pain usually ceases. It has been stated that the closure of an upper wisdom on to the flap of gum that may partially or completely cover an erupting lower wisdom, is a frequent cause of pain, and that the extraction of the upper wisdom relieves the pain, and enables the lower tooth to erupt. Cases occur in which the gum and peridental membrane become acutely inflamed, causing great pain, either from local or constitutional causes. In some of these cases the cause is unapparent or unascertainable. The application of strong tincture of iodine to the gum and the removal of tartar, when it is present, is generally the best local treatment. Some of these cases may easily be mistaken—if only one or two adjacent teeth are affected, and these teeth contain fillings—for peridental inflammation, caused by an inflamed or a dead pulp.

Pain after the extraction of a tooth is best relieved by packing the socket with cotton-wool or lint saturated with a paste of orthoform and water, or orthoform and alcohol; or the socket may be filled with either the paste or the dry powder, and the orifice sealed with a ball of cotton-wool saturated with mastic or sandarach varnish. In some cases

it will also be necessary to cauterise and stimulate the socket with creosote, carbolic acid, or nitrate of silver. Burring out the socket, especially at the apex, has been recommended in certain cases, but the writer has never found it necessary to resort to this, and the cases in which it is advisable may be considered rare. A frequent cause of pain after extraction is a rapid healing of the gum at the orifice of the socket. This often causes the gum to curl over the sharp edges, and practically stretch or press itself tightly on to them.

In these cases the gum should be slit in several places with small scissors, cauterised with nitrate of silver, and kept away from the ragged edge of the socket with cotton-wool and sandarach varnish. The relief of pain in teeth which contain either inflamed or dead pulps is often rendered difficult, and sometimes impossible (unless extraction is resorted to), owing to the formation of either secondary dentine or pulp stones. In all cases, therefore, where the pulp does not appear to be exposed, and the application of the usual remedies fails, the pulp-chamber must be drilled into if possible, and if found to be filled up with secondary dentine, it must be cut away until the orifices of the root-canals are exposed. The presence of what are known as pulp stones often causes severe pain,

which is difficult to relieve, owing to these stones forming a barrier to the absorption of whatever remedy may be applied. Two distinct causes of pain may exist in a tooth that has more than one root-canal. One canal may contain a highly inflamed pulp, and in the other one the pulp may be dead and in a septic state. These conditions will be still further complicated if there is much formation of secondary dentine. It is always advisable, whenever it is possible to do so, to ascertain the exact conditions by free excavation, for in these cases the pulp in the crown of the tooth (or pulp-chamber) will be either dead or have turned itself into secondary dentine.

Rhizodontrophy is the operation of relieving pain due to a dead pulp, or preventing its recurrence after filling in these cases, by drilling a small hole into the pulp-chamber, just under the free edge of the gum, usually on the buccal or labial surface, and at right angles to the long axis of the tooth, thus forming a vent for the escape of the gases of decomposition, and sometimes pus.

Some operators, instead of cleansing and filling roots, perform rhizodontrophy whenever called upon to fill pulpless teeth, or to save the trouble of drilling out a filling and treating the roots when a pulp has died under a filling. This is a slovenly

practice, which cannot be too strongly condemned. Occasionally it may prove of great value, when a patient, for instance, is about to leave the neighbourhood, and there is no time to give relief in any other way; or in cases where, owing to a highly inflamed peridental membrane, it is impossible to cut out a filling or open into the pulp-chamber through the cavity of decay. In many of these cases the tooth may be supported on the lingual side by the thumb or fingers, and drilling through the neck of the tooth at right angles may be quite bearable. In these cases the vent-hole is not to take the place of root treatment and filling, but is used as a means of enabling it to be subsequently carried out, when, of course, the vent-hole will be filled up.

It is, however, decidedly preferable to open directly and freely into the pulp-chamber through the cavity of decay, or by cutting out a filling when necessary, whenever it is possible to do so. It is often impossible, except by ocular or instrumental proof, to know whether the symptoms are caused by a dead pulp or by one that is inflamed, and if, as may easily happen, rhizodontrophy is resorted to in a case in which the pulp is alive, or in a case in which the pulp-chamber happens to be filled up with secondary dentine, it will be a worse than

useless proceeding. It is therefore an operation only to be resorted to in the extreme cases already mentioned, and also where, owing to exceptional difficulties of manipulation, or extraordinary resistance of a tooth to the usual treatment, it may be the means of preventing the extraction of a valuable tooth. It is not, however, a very nice thing to leave a tooth in such a condition that foul odours escape from it into the mouth, but cases do occur in which it is distinctly advisable to save a tooth even if its retention demands rhizodontrophy. Notwithstanding the fact that toothache, if intelligently diagnosed, generally rapidly responds to local treatment, there are cases in which systemic treatment in addition is necessary if the patient is to be relieved from pain as speedily as possible. Acute peridental inflammation may also cause constitutional disturbance which should be medically treated.

A dentist, if he thinks good, may advise patients to take one of the ordinary household remedies, such as a simple, innocuous purgative; but for anything beyond this they should be referred if necessary to a medical practitioner.

CHAPTER II

REMOVAL OF TARTAR

After attending to any teeth that have ached, it is always advisable to remove all tartar from the teeth. This is often a tedious and usually an uninteresting operation, and its proper performance is frequently neglected. To remove tartar in a neat and efficient manner, with as little laceration of the gums as possible, demands considerable skill, and often considerable time. No exact rules can be laid down for the performance of this operation, for both the operative technique, as well as the selection of instruments, will greatly depend on individuality.

For general purposes the removal of tartar may be described as best effected by first breaking up or chipping away the main bulk of the incrustation, and then scraping away the smaller particles that are left adhering to the teeth. To begin with the lower incisors; it will often be found that passing a very thin, chisel-like scaler between the necks of these teeth from the front dislodges a good deal of the deposit from the lingual surfaces. If this can-

not be easily accomplished, the No. 1 Howe scaler, or some similar instrument, may be applied to the lingual surface, forcing the sharp point downwards and sideways in the direction of the interproximal spaces. This readily breaks away the tartar that covers the interstices between the teeth, and the mass that remains on the lingual surface of each tooth can be frequently dislodged in one piece by placing the point against the ledge or projection that is left at the sides of the teeth, and lightly levering sideways.

Cutting into the tartar in the direction of the gum with a suitable chisel, or placing the edge of the No. 4 Allport scaler underneath the tartar at the gum line, and levering or pulling upwards, or in the direction of the cutting edges of the teeth, may also be resorted to with advantage. Nos. 11, 12, 13, and 14 of the Abbott set (the second or later set) have similar cutting or scraping edges to the No. 4 Allport instrument, and are very conveniently curved for use on bicuspids and molars, particularly in the lower jaw. The instrument that has in itself the widest range is the No. 1 of the Howe set, and it can be used in any direction as a cutter or breaker-up of the tartar, as well as a scraper. For scraping the surfaces of the teeth quite smooth, by removing every particle that

adheres to them, spoon excavators of various sizes and curves are useful. Nos. 15 and 16 of the Darby-Perry set of excavators (S. S. White's list) are particularly valuable for scraping the lingual surfaces of lower incisors and canines, and when these surfaces are difficult to reach, the No. 3 long-bladed Woodhouse excavator can often be conveniently applied. No 150 of the Dental Manufacturing Co.'s list of excavators is also a very useful curved spoon excavator. In working at the back of the lower incisors the operation may often be most conveniently and accurately performed by reflection, and this use of the mouth mirror is a necessity if these teeth lean inwards. Much care is needed in order to remove tartar from between teeth, and slender, chisel-like scalers are most useful in narrow spaces. It may be mentioned that tartar is never completely removed unless the teeth feel smooth to the patient's tongue, and this condition should be secured before any polishing powder is applied. With the exception of removing superficial stains or discolorations, very little polishing with powder is needed if the tartar is completely and carefully removed. In removing stains, finely powdered pumice-stone may be applied with a properly trimmed stick of orange-wood. Tincture of iodine also assists in removing stains, and may be safely

used. Acids are sometimes necessary, but should always be used with discretion, and only when necessary. Sulphuric acid up to 50 per cent. is generally selected, but a sufficiently strong solution of *aqua regia* will often act more promptly. Bicarbonate of soda should be applied immediately afterwards in order to neutralise the effect of the acid on the enamel, and if the teeth are then well rubbed with an orange-wood stick charged with soap, they will feel smoother and more comfortable. Polishing can be effected with fine pumice-stone, applied on labial surfaces with the orange-wood stick, and on lingual surfaces, or wherever the straight stick cannot be readily applied, wooden or leather wheels may be used in the dental engine. Circular brushes are often used, but are apt to cause much spattering about of the powder. If thought good, finely-powdered Hindostan stone, and finally, precipitated chalk may also be used.

CHAPTER III

PYORRHŒA ALVEOLARIS

It would be out of place in a book of this description to criticise the term Pyorrhœa alveolaris, or to attempt to go into the etiology of the disease. For practical purposes it may be said to consist in a wasting away, or decay, or absorption, of the sockets of the teeth which proceeds usually in a more or less irregular manner, and then, in consequence of lack of support, the teeth become loose, and if the disease runs its course unchecked, the teeth finally drop out, or have to be extracted. During the progress of the disease small brown scales of an exceedingly hard and adherent tartar are deposited on the roots, in places where the alveolar process has disappeared. This has been given the name of sanguinary or serumnal tartar, as it appears to be deposited from the exudations of the diseased tissues, and not from the saliva. The destruction of the sockets of the teeth is accompanied by a slow or chronic state of inflammation of the peridental

membrane, and the membrane itself becomes destroyed as the disease progresses.

Every now and then cases occur in which the chronic or painless state becomes acute, and if the tooth is extracted a mass of thickened and inflamed tissue is found at the end or side of the root. There is every reason to believe that the disease originates in an irritated or inflamed peridental membrane, and that anything that irritates and inflames this membrane may cause the disease. There is also reason to believe that the variations, the progress, and the curability of this condition, do not so much depend on its immediate cause, as on the constitution or state of health of the patient, and the length of time the disease has existed. Its cause may be local or constitutional. Anything that will irritate the membrane sufficiently to prevent its recovering its normal state will always, in the absence of treatment, result in the loosening and loss of the teeth. It is only a question of time.

Local irritation may take the form of tartar, malocclusion, or the presence of any foreign body under the gum. The effect of local irritation on the peridental membrane, is manifest to any one who has accidentally left a silk ligature on the neck of a single-rooted tooth after removing the rubber dam, and the effect of malocclusion is easily

proved by leaving a hard gold filling too high on an occlusal surface. It is well known what a state the mouth and gums are in during a severe illness, and as the gums and the peridental membrane are intimately connected, it becomes merely a question of the spreading of the local inflammation—or unhealthiness—to the peridental membrane for it in its turn to be affected. It is no uncommon thing for a patient's gums to be red and puffy and bleed easily for some considerable time after recovery from an illness; and there is every probability, in the event of the generally inflamed condition of the mouth spreading to the peridental membrane, that pyorrhœa will be established, unless the vitality of these tissues is sufficient to enable them readily to resume their normal state with the general improvement of the patient's health. Deposits of crystals of uric acid on the apices of roots have been put down as the sole cause of the disease. That deposits of some kind do take place at the apices of roots in some cases is certain. That absorption and roughening of the apices of roots also sometimes takes place is true. But that the disease depends on the peridental membrane being attacked in a certain way (not necessarily always the same way), and on the kind of resistance (or the want of it) that nature puts forth (or is able to put forth) in any particular

case, may be accepted as a common-sense view in the present state of our knowledge in regard to this disease in particular and predisposition in general.

If the value of the natural teeth were better understood and appreciated, and if the almost hopelessness of satisfactorily treating this disease in an advanced condition were realised, it would be customary for medical men to send their patients to a dentist as soon as they had recovered sufficiently from an illness to be amenable to dental treatment. By this means many cases of pyorrhœa would be either prevented or rapidly checked.

The treatment consists in removing all sources of mechanical irritation by first of all removing the tartar from the roots. This is imperative, as unless it is completely removed success cannot be expected. Elongated teeth must be shortened in order if possible to free them from the bite, and teeth that are very loose must be firmly held in position by ligating them to firm teeth with soft platinum wire or by means of some firmly fixed mechanical appliance. Nature is thus given a chance to repair lost tissue, and when this is effected the ligature or appliance should be removed. The removal of tartar from the roots is difficult to accomplish. It must be done almost entirely by the sense of touch, and the scales are often so firmly

adherent to the root and project so little that there is the greatest possibility of the instrument slipping over them without the operator being conscious of their presence. This may to a great extent be avoided by using the No. 4 Allport scaler (Fig. 1).

Fig. 1.

This instrument—or some similar one—should be inserted as deeply as possible into the pocket, and the cutting edge made to bite into the cementum, so that the root itself as well as the tartar is scraped. The root is denuded of periosteum where this tartar is deposited, and the slight scraping of the cementum will do no harm, and is infinitely preferable to leaving particles of tartar, for where any of these are left the parts rarely, if ever, improve.

When the deposits are removed, and, if necessary, the teeth are firmly braced by ligatures or an appliance, the pockets and edges of the gum should be treated with escharotics, antiseptics, or astringents as may seem good. Chloride of zinc, in proportionate strength to the requirements of the case, is a most valuable remedy, as it combines all the desired properties, *e.g.*, it is an escharotic, an astringent, and an antiseptic, and can be used full strength or diluted as the circumstances of the case demand. In full strength, or approaching this, it

will generally cause some pain. The various remedies that have been used with more or less success are well known and need not be mentioned. Solutions of sulphuric acid, or aromatic sulphuric acid full strength, have been recommended, and certainly help to clean out the pockets. Tincture of iodine applied to the gums is most useful, and there are few cases where, if it was only applied early enough and frequently enough, it would not check peridental inflammation sufficiently to either entirely prevent pyorrhœa, or, at any rate, render its subsequent treatment easy and satisfactory.

Success in the treatment of pyorrhœa is often doubtful and sometimes impossible. If the sockets of the teeth are very much destroyed, and the teeth are causing annoyance, it is better in the majority of cases to extract them. If, on the contrary, the destruction is not very extensive, and particularly if only a few teeth are involved, the treatment may be undertaken with every probability of, at any rate, greatly improving the conditions and in some cases effecting a complete cure. In others, although the lost tissue is not completely restored, the teeth will become firm and useful in mastication, and the disease is for all practical purposes cured. Much, however, will depend on the patient's vitality or health. Very delicate or weakly individuals, and

especially those who are suffering from some chronic ailment or disease, are not good subjects. The thorough removal of tartar from the roots on which so much depends, frequently causes pain. The introduction of cocaine into the pockets will often mitigate this, but sometimes appears to have little or no effect. A great deal depends on the temperament of the patient, and there are nervous, irritable individuals for whom the operation cannot be satisfactorily carried out, and the loss of whose teeth is in consequence only a matter of time.

During the treatment and for some time afterwards the patient should be instructed to frequently use an antiseptic and astringent mouth wash. One of the best washes for these conditions is chloride of zinc, used in the proportion of from one to four grains to the ounce of either rose water or orange-flower water. Unfortunately, however, it is so disagreeable that few patients will persist in its use. It is very important when a good result is obtained for the teeth to be carefully scaled at regular intervals.

CHAPTER IV

FILLING TEETH

A DESCRIPTION of the filling of teeth may be divided into a consideration of, firstly, the materials, and, secondly, methods of using them. As is well known, the materials employed are gold, tinfoil, amalgams, gutta-percha, and the various cements, or osteo fillings, as they are often called. To the above must now be added porcelain in the form of inlays.

Gold.—This precious metal is prepared for filling teeth in a variety of ways. It is prepared in the form of foil of varying thicknesses, and also as a sponge-like mass generally known as crystal gold. Foil is prepared either as cohesive or as non-cohesive gold.

Absolutely pure gold possesses the property of welding when cold, providing the surfaces to be united are perfectly clean and dry. The least deposit on the gold, either of moisture or any extraneous substance, interferes with this welding, and, consequently, it is always necessary to anneal

it before use, in order to drive off anything that may happen to have collected on its surface. This welding property is made use of by the majority of dentists in making gold fillings.

Non-cohesive gold is so prepared that there is no possibility of one piece sticking to another. Any welding is quite out of the question, and the filling is made by so wedging and interlocking the pieces of gold together in a cavity that it forms a tight, dense plug. This non-cohesive property is probably attained by subjecting the leaves of pure gold foil to some vapour which deposits something on its surface. If this non-cohesive gold is annealed, it will sometimes be noticed that a vapour is given off, and when brought to a dull red heat it becomes, as a rule, thoroughly cohesive. There are a few makes of non-cohesive gold which become so slightly cohesive on being fully annealed that this does not prevent their being worked non-cohesively. These foils, the character of which is only slightly changed by annealing, are often spoken off as "true, non-cohesive gold." They *can* be worked cohesively, but it demands special care and manipulation. What it is that gives them this particular property is a trade secret. It has been stated that it is due to the addition of a very small quantity of alloy to the gold. These true, non-cohesive foils, however, seem

also to have been subjected to the action of some vapour, for, as above mentioned, they are not so absolutely non-cohesive when annealed, and heating them causes a vapour to be given off, just as with other makes of non-cohesive gold. This vapour will only occasionally be noticed with any kind of non-cohesive gold, and no doubt is due to an excess of whatever has been deposited on its surface.

Intermediate between the non-cohesive and the cohesive gold is a kind known as semi-cohesive. The name semi-cohesive attached to a make of gold is sometimes misleading, for it will almost always be found necessary to anneal it before use (as it is worked on the cohesive principle), and it usually becomes cohesive when well heated. There are, however, makes of true, semi-cohesive gold, of which the semi-cohesive globe-foil was an excellent example. This kind of gold when fully annealed is still semi-cohesive.

If non-cohesive gold of the kind that becomes cohesive when fully annealed is lightly annealed on a sheet of mica an excellent semi-cohesive gold may be produced, although it demands great experience in order to hit the happy medium between under- and over-annealing it. Non-cohesive gold is often termed soft gold, while cohesive gold is often spoken of as hard gold. Semi-cohesive gold is frequently

described as either soft gold or soft cohesive gold.

There is so much confusion of terms and misunderstanding of the properties of gold in its various states or conditions that an attempt at explanation may not be out of place. It has been stated that the softest gold in itself is the cohesive variety. It is also well known that annealing a bar of gold brings it to the softest possible condition, just as it is well known that it can be hardened by hammering. In speaking of soft and hard golds, so far as filling teeth is concerned, we mean the softness or hardness of the metal during its manipulation, and the comparative hardness of the filling when it is completed. There is no doubt that fully annealed gold becomes harder during its manipulation in a tooth, and the resulting filling is harder when completed than one that is made in exactly the same way with slightly annealed gold, and the less the gold is annealed the softer it will work and the softer will be the filling. It is presumed that the gold in these cases is welded into a coherent mass. All this is difficult to account for. The fact that the layers of fully annealed gold in a pellet, cylinder, or strip stick together very quickly during the process of packing, and that consequently a more resistant pellet is produced, does not account for the greater hardness of the

completed filling, and no satisfactory explanation is forthcoming.

Semi-cohesive gold, if manipulated with a mallet, can be condensed into a perfectly coherent mass, the density of which (density and hardness are not synonymous terms) cannot be surpassed with cohesive gold. But if hand pressure is used with both of these kinds of golds the cohesion produced with the semi-cohesive variety will usually be inferior, although in many cases it may be sufficient for all practical purposes. The advantage of semi-cohesive gold is that it is a little more adaptable than cohesive gold, and consequently excellent adaptation, and an even condensation, may be produced with larger pieces or with broader ended pluggers.

Crystal Gold. — So much misconception exists concerning crystal gold, and so many misleading statements have been made in the past, and continue to be made at the present day, about this form of gold, that it may not be out of place to quote from an article "On the Value of Crystal Gold in Dentistry," by the late Dr. N. W. Williams, in the *International Dental Journal*, February 1892. After stating that crystal gold was first brought to the notice of the dental profession in 1855 or 1856, and was the invention of Professors George Watt and J. Taft, and describing the process of its manu-

facture, he (Dr. N. W. Williams) goes on to say:—"The process being somewhat difficult and complicated, and attended with some danger to health, the inventors were never able to make it in sufficient quantities for sale, and the profession were deprived of a very valuable aid in operative dentistry. Becoming associated with Professor Watt in 1865, we continued to make it for our own use during the seven years of our association, and I have never before or since filled teeth with greater satisfaction to myself and patients. The crystal gold known under the name of A. J. Watts' crystal or sponge gold was brought out about the same time as that of Watt and Taft. At first it was not a success, as complaints were made that it discoloured in the mouth and did not give a perfect filling at the margins. This may have been due in part to bad manipulation, for, being very spongy, one was inclined to use it in too large pieces, and then it would harden under the instrument before it was condensed throughout the mass. The makers of this gold have steadily improved it, until now it is a very valuable gold for saving teeth." It is stated ("Items of Interest," 1901) that Dr. N. W. Williams showed the late Dr. de Trey how the original Watt and Taft's gold was made, "the outcome of which is the Solila gold of to-day."

The writer has made considerable use in his practice of A. J. Watts' crystal gold during eighteen years, and has always found it to be an excellent and reliable preparation. He has also used several of the more modern productions, and finds some of them appear to be very good preparations. A good make of crystal gold is a fascinating kind of gold to use, and although one who is accustomed to foil may at first fail to satisfy himself, it will be found that a familiarity with the material rapidly causes any difficulties of manipulation to disappear, and one soon forgets that its use was ever attended with difficulty or disappointment. It is very important, however, to realise that it is extremely easy to make bad fillings with crystal gold, and that those preparations which possess the property of "staying in place" in a cavity without rocking or balling up, no matter how large the piece may be, or how carelessly it may be placed in position, lend themselves particularly well to imperfect work. If a crystal gold filling is to be welded into a coherent mass (and the very structure of this gold particularly demands this) and well adapted to the cavity walls, it must be worked with as much care and thoroughness as cohesive foil. All the rules that apply to foil fillings apply with equal if not greater force to crystal golds, with the excep-

tion that with some makes of crystal gold the filling can be easily started without pits and without resorting to wedging in a base of non-cohesive gold. This very quality may, however, tempt an operator to fill an improperly prepared cavity, often with disastrous results; and the very general temptation to stuff a cavity full of crystal gold, and imagine, because each piece stays in place and the surface finishes up smooth and hard, that the filling is both well condensed and accurately adapted, will, as a rule, result in a disappointment that is often attributed to the gold instead of to its mal-manipulation.

It is amusing to hear crystal gold lauded *because* it can be used successfully with hand pressure, just as if good hand-pressure fillings could not be made with foil. It is appalling to see broad-faced pluggers used exclusively throughout the whole operation of packing and condensing this gold—particularly if hand pressure is resorted to. A few experiments made out of the mouth and a careful examination of the interior surfaces of the plugs, will convince any one that the principles that govern the making of cohesive fillings with foil apply with equal force to crystal golds, and that the best way to accomplish first-class fillings with crystal gold is first to "serve an apprenticeship" to foil. The reason for this will be made plain by the following quotation

from "Principles and Practice of Filling Teeth," by Dr. C. N. Johnson, page 172, first edition:—"The chief distinction in this connection between foil and crystal gold is that foil demands care, and so expresses itself at every turn, while the other demands equal or greater care, but seems constantly to give the impression that it does not."

Crystal gold should be carefully torn up or separated into smaller pieces with fine-pointed foil carriers or tweezers, or with needles set in handles; cutting it up, even with a razor, compresses it in an undesirable manner. Within reasonable limits the looser the texture of this gold the better — the No. 1 Watts' crystal gold in the block or cake form, for instance, is the most satisfactory form of this particular make. Different makes or preparations of crystal gold vary somewhat in their working properties, and admitting that some makes may be better than others, it may easily happen that an operator will prefer a certain preparation merely because its working properties suit his fancy.

Any attempt to institute a comparison between the various forms of crystal gold that are now manufactured would demand a large number of carefully carried out experiments, in the absence of which the writer does not feel justified in expressing an opinion in these "Notes" as to their relative merits.

Crystal gold lends itself quite as well to mallet work as foil does, and—just as in the case of foil—the greatest condensation and the best adaptation will be produced with accurately applied mallet force. The structure of crystal gold does not favour the use of the sliding blow, or wiping action, that is so frequently employed when the fast-striking engine or electric mallets are used. The automatic, the pneumatic, and the hand mallet will therefore usually give the best results with crystal gold. The pluggers should be finely serrated, or just sufficiently rough to prevent slipping. Any forms of pluggers that will give good results with foil may be used with equal satisfaction with crystal gold. If a good make of crystal gold is properly and thoroughly manipulated, quite as good results can be obtained as with foil.

Some operators will doubtless find that crystal gold enables them to work more easily, more rapidly, and quite as efficiently, if not more efficiently, than with foil; but there are other operators who can manipulate foil quite as easily, rapidly, and efficiently as the most expert workers with crystal gold. It is the man and the method and not the material that makes for success, although individuality will always play a great part in selection of material and results obtained with it.

Methods of Preparing Gold Foil.—Gold foil is prepared for introduction into teeth in the following ways:—By simply tearing small pieces from the sheet with tweezers or foil carriers; by rolling or twisting the sheet, or part of it, into a rope, and then cutting it up into small pieces, or pellets as they are termed; by folding the sheet flat upon itself several times, and then cutting it into strips, or tapes, of convenient length and width; by further cutting these strips into small squares; by cutting the sheet into strips and rolling them round a spindle into a cylinder-like form; by tearing small pieces from the sheet and rolling them into little balls; and by cutting strips or squares from a sheet of very thick foil. Different operators use one or more of the above-mentioned methods of preparing the gold, as may seem best to them. The most intimate union of the molecules of the gold, producing the most perfect welding, density, and hardness is doubtless obtained by the use of small, flat squares, providing each one is packed flat without any curling up or doubling of the edges. This is, however, a very tedious and slow method of working, and the majority of operators will find they obtain practically as good results by more rapid methods. The use of these squares for building up or perfecting the surfaces of fillings is a practical

proceeding, and no better surface or finish can be obtained than in this way. No. 4 foil, folded up to No. 128, viz., 32 thicknesses, or layers, of the No. 4 foil, and cut into these small squares, can be used for surface work with great satisfaction if properly annealed.

Small pieces of foil torn from the sheet may be used for filling minute cavities, or parts of cavities (especially starting pits and fine grooves) that are difficult of access. Pellets or cylinders have a wide range of usefulness, but balls of gold foil will generally be found too resistant to be accurately adapted and condensed by the cohesive method. In using strips or tapes of gold it is important they should not be too thick. The building up of contours, and the filling up of the middle of large fillings, may be satisfactorily effected by means of strips containing eight thicknesses of No. 4 foil, and ten thicknesses and even sixteen thicknesses may be used for building up, but accurate adaptation and density is best attained by confining oneself to four thicknesses of either No. 4 or No. 5 foil, producing No. 16 with the No. 4 foil and No. 20 with the No. 5 foil. The writer has no desire to speak dogmatically on this subject, but he distinctly deprecates the use of thick tape against cavity walls, and believes that, all things considered, the No. 16 strip is the best

form of gold for producing accurate adaptation and great density. Pellets or cylinders in the cohesive or semi-cohesive state should be loosely rolled. The best cylinders for cohesive or semi-cohesive work are those purchased ready-made. As a rule they are made of very thin gold, and the smaller sizes, by reason of their delicacy, should be particularly applicable against cavity walls when hand pressure is used. Cylinders—probably owing to the extremely thin foil of which they are made—are not so reliable as foil, inasmuch as their quality seems to vary. There is very rarely any trouble with foil in this respect, but it is not uncommon to find one bottle of cylinders work perfectly, and the next one prove most unsatisfactory when the gold is annealed. Heavy foil, such as No. 30 or No. 60, is principally useful for surfacing fillings, although some operators use the No. 30 heavy foil in strips of single thickness for filling large cavities. In using heavy tape, such as single strips of heavy foil or the lighter foil folded into a heavy tape, it is usually necessary to pack each layer flat, by attaching one end to the gold already in place, and then carefully folding the strip backwards and forwards on itself, layer by layer, taking care to weld each layer absolutely flat to the already condensed gold. If thin tape, such as four folds of No. 4 foil (producing No. 16), is

used, the end of the strip may be attached to the gold that is already in the cavity, without any particular care being taken as to whether it is packed flat or not. The point of the plugger is then placed on a part of the projecting strip in such a manner that one, two, three, or more layers are simultaneously packed down and condensed, the gold being worked on the whole fairly flat. Irregular masses of gold, such as pellets cut from a rope, or little balls (if the latter should ever be used), will not, as a rule, produce such hard and evenly condensed fillings as the flatter forms. This is shown by these fillings often becoming pitted or roughened by the force of mastication. This can be avoided by making the surface of tapes or squares.

Manipulation of Gold.—Decidedly the best cohesive gold-work is accomplished by means of a mallet, providing the cavity admits of a mallet plugger being accurately used. Many cavities demand the use of right-angle or curved pluggers, but the writer, after trying four right-angle mallets, found none of them satisfactory.

Many operators—particularly in countries where patients consider gold fillings an ornament to their teeth — do not hesitate to cut away part or the whole of labial walls in incisors and canines in order to use a mallet. This is a proceeding that

is strongly objected to in the British Isles, and for this reason—as well as for the reason that it is impossible to prepare many posterior cavities in such a manner that a mallet can be used—hand pressure has to be greatly resorted to. It is almost if not quite impossible to produce *perfect* adaptation with cohesive or semi-cohesive gold and hand pressure, consequently both the instruments and the gold should lend themselves to the production of the greatest possible adaptation and condensation. The plugger points should be as fine as practicable, and the pieces of gold should be small, and in working against the walls they should only be sufficiently annealed to enable the work to proceed satisfactorily.

In dealing with mallet work we are confronted with several problems which, although easy of solution, have not yet been solved. This is doubtless due to the great amount of work that would have to be undertaken by several men before accurate conclusions could be arrived at. So much depends on an individual's skill and method of manipulation that a comparison of similar experiments carried out by a number of operators is needful. The condensation and adaptation of cohesive gold depends on accurately applied force. What we want to know is the exact relationship that the force of the blow, the size of the plugger point, and

the form and thickness of the gold bear to one another.

The finer the point—in reason—the greater the condensation and the better the adaptation. The heavier the blow, the better is the adaptation and condensation. The more favourably the gold is prepared for ease and accuracy of adaptation and condensation, the more surely will these be obtained. The difficulty is not so much in making fillings sufficiently hard and strong to resist the wear and tear of mastication, as to save teeth by perfectly adapting the gold, and it may be said that any method which will insure perfect adaptation with cohesive gold will surely produce a well-condensed filling, providing the whole of the filling is made with equal care. Starting with the point that thin strips of gold, or small cylinders, lend themselves particularly well to adaptation, and selecting what is known as a retaining point plugger, viz., one with a condensing surface of $\frac{1}{64}$ inch in diameter, as the point that produces the greatest condensation and adaptation, we must not forget that when the fine plugger is applied to adaptable gold with great force, an altogether unnecessary amount of time and energy may be expended. The comfort of the patient and the well-being of the peridental membrane render the use of excessive mallet force undesirable, and a

light or light medium blow should be used in all ordinary cases. The question to be settled is therefore principally confined to size of plugger and forms of gold. The condensing power of the fine point gives it a fairly wide range as to the form of gold that may be used in connection with it, and the more favourable the form of gold, the greater the latitude in the selection of sizes of pluggers. It has also been pointed out that semi-cohesive gold may be used in slightly larger pieces than the fully cohesive, and it consequently happens that gold in the semi-cohesive state still further somewhat increases the range or latitude of forms of gold and sizes of pluggers.

To go further into this question would lead to confusion, but as an illustration of the writer's meaning, he may select the following examples from a number of experimental fillings he made in a steel block, using a mallet force (medium or light medium), which rarely causes a patient any inconvenience.

Strips of No. 4 foil folded up to No. 16, packed and condensed with a plugger point three sixty-fourths of an inch in diameter, produced *perfect* adaptation, and a specific gravity of 18·9.

With the same sized plugger and same amount of force, strips of the same gold folded up to No.

32 produced bad adaptation, and a specific gravity of 17·5.

Reducing the size of the plugger point by half, produced a good—but not perfect—adaptation of the No. 32 strips, and a specific gravity of 18·4, Pellets cut from a loose rope of one-third of a sheet of No 4 foil, packed and condensed with the three sixty-fourths of an inch plugger, gave a similar adaptation to the No. 32 strips, manipulated with a plugger of half this size, and produced a specific gravity of 18·1.

Pellets cut from a half-sheet roll of No. 4 foil produced *perfect* adaptation with a one sixty-fourth of an inch plugger. The specific gravity was not taken in this case.

The gold in these experiments was fully annealed on the electric annealer, with the exception of the last case, in which the naked spirit-lamp flame was used.

Seven experiments were made with hand-pressure, using various sizes of pluggers, and gold prepared in the form of pellets and cylinders. With a plugger-point just over one thirty-second of an inch in diameter it was found the fillings made with unannealed gold were better adapted than those made with fully annealed gold and the same plugger. The best adaptation was obtained with small cylinders (Morgan Hastings' extra pliable

burnish gold cylinders, No. ½ size, were used), and the specific gravity of this filling was 17·6. The same cylinders, fully annealed, packed, and condensed with a one sixty-fourth of an inch plugger, were not quite as well adapted as when manipulated in the unannealed state with the broader plugger. The specific gravity was 17·1. In making the hand-pressure fillings greater force was used than can be employed in the mouth. The object was to ascertain if the adaptation obtainable with great hand-pressure could be compared to that produced with moderate mallet force. The conclusion arrived at—as already explained—is that a very excellent —though rarely, if ever, perfect — adaptation is obtainable with hand-pressure in the mouth, *providing* the form of gold, the annealing of the gold, and the size of the pluggers used are such as lend themselves particularly well to the attainment of the desired result. Two good makes of crystal gold were also tested with mallet force and hand-pressure, and were found to be almost if not quite as adaptable as the most favourable forms of foil. Any slight difference in the adaptation was probably due to the pieces used being relatively larger than the pieces of foil.

The specific gravity tests were made in the usual way by weighing the plugs in air and in water.

Some recent experiments conducted by the professor of chemistry who made these tests have convinced him that the usually adopted method is inaccurate as far as testing the density of gold fillings is concerned. Four fillings that had been saved when the rest of the original experimental plugs were consigned to the scrap gold box and melted up, were then re-tested by a more accurate method (for description of which see Appendix) with the following results:—The mallet filling made with strips of No. 16 foil, which originally came out 18·9, now comes out 18·66; the hand-pressure filling made with unannealed cylinders, originally 17·6, is now 17·54; a crystal gold filling made with a mallet is reduced from 18·5 to 17·55; and a hand-pressure filling made with unannealed crystal gold, that was originally determined as 18·4, is now 17·13. This does not necessarily prove that very dense fillings cannot be made with crystal gold. It points, however, to the advisability of determining as far as possible the size of the pieces of crystal gold that should be used if density of the filling is desired. These re-tests were received after the pages dealing with crystal gold were in the press, and they certainly emphasise the remarks made as to the necessity for the most thorough and careful manipulation of crystal gold. These

experiments are far too limited, and as a dentist is not a machine that works always with mathematical accuracy, it has been pointed out that a very great amount of work is necessary in order to arrive at completely accurate conclusions.

They point out, however, as well as do some other experiments that the writer has not thought necessary to allude to, that certain forms of gold are more favourable than others, that a fine-pointed plugger is in itself better than a larger one, and that unannealed gold (providing it can be made to stick) produces in itself superior adaptation and density whenever the mallet force necessary to obtain a high degree of excellency with fully annealed gold cannot be employed. It has been mentioned, however, that density and hardness of a filling are not synonymous terms, and this also applies to cohesion. There is every advantage in using unannealed or lightly annealed gold against the walls of cavities, particularly if hand pressure is used, but the writer considers that the bulk of a hand-pressure filling that is made by the cohesive method should usually be made of fully annealed gold.

There is also no doubt that the specific gravities above mentioned can be considerably increased if a favourable form of gold is thoroughly well condensed with a fine point and great mallet force. It

must not however be forgotten, that the exclusive use of a fine point may reduce density by pitting into the filling, and that the use of a medium point, followed by a fine one, will prevent this, and in many cases give the best result. Such fillings have been made to considerably exceed the density of a button of melted-up pure gold, but it is very doubtful if this extreme density, or even a close approach to it, can be made as a regular thing in the mouth, and a filling made in the mouth that approaches a specific gravity of 18·0 will usually be considered exceptionally dense. The specific gravity of a melted-up piece of S. S. White's gold foil is 19·0.

It is often a convenience to pack and condense each piece or layer of gold with a medium-sized plugger, and then to further condense it with a fine point. This, as already mentioned, may prevent pitting, and result in a better and more even condensation and adaptation. When gold is condensed with a fairly broad plugger so thoroughly that the operator feels sure of perfection, it is wonderful how often the gold will still further "go down" when the fine point is applied.

The method of manipulating non-cohesive gold is entirely different from the cohesive method, and the accurate adaptation of non-cohesive gold does not so much depend on the greater adaptability of the

gold itself, as upon the fact that it lends itself to the employment of enormous force. The wedge is the greatest force in mechanics, and it is on the power exerted by the wedge that non-cohesive gold fillings mainly depend for their excellence. The force that may be used is only limited by the strength of the cavity walls, for the lateral compression of the gold by means of the wedge does not jar the tooth or hurt the peridental membrane. It is quite easy to split off one or more of the cavity walls by wedge power, and this demands discretion in regulating the force.

The great difficulty with non-cohesive gold is in obtaining or producing cavities of the right shape and accessibility. An ideal cavity may be said to be one of medium to large medium size on the occlusal surface of a first lower molar. Here strong walls of sufficient height or depth can be secured at right angles to a flat floor. The gold can be readily inserted in layers parallel to the walls, and the wedge-shaped plugger can be driven into the gold at any part parallel to the walls and at right angles to the surface of the filling.

The holes made by the wedge can be solidly filled up by driving non-cohesive gold into them, and the most even and thorough condensation of this gold is arrived at, producing a filling that is not only per-

fectly well adapted, but will stand the wear and tear of mastication.

Just as this freedom and accuracy of manipulation is interfered with in any case, and just as the shape or depth of the cavity and the strength of the walls departs from the ideal condition, so will the difficulty of making well-adapted and solid non-cohesive fillings be increased. Gold foil is prepared for non-cohesive work much in the same way as for the cohesive method. When pellets or cylinders are used, they should be rolled more tightly, and a thicker gold than that usually employed for cohesive cylinders is advisable, No. 4 or No. 5 foil being usually preferred. Cylinders are now generally used for non-cohesive work, but those that are supplied by the depôts for this kind of work are often too stiff to be easily used in approximal cavities. Useful cylinders can be made as follows:—Take a sheet of No. 4 non-cohesive foil, fold it once on itself, cut a strip the length of the sheet, one or two inches broad, double over the end of the strip with straight, fine-pointed, foil carriers or tweezers; then with the tweezers, supplemented with the fingers, gently roll the gold strip. Keep the tweezers outside the roll, do not wrap the gold round the points. By proceeding in this way, always catching hold of the external part of the roll, and cutting off the superfluous strip

as soon as the cylinder or roll is thick enough, various sized rolls are easily made. Cut the roll into short pieces of the desired lengths with sharp scissors. The scissors will compress the ends somewhat, and produce blocks rather than cylinders. A little gentle squeezing and rolling with the fingers will bring them back to the cylinder form, although as blocks they will work satisfactorily. Some of the best non-cohesive fillings of the past were made by operators who confined themselves solely to tape. For general purposes it will be found that pellets, or short lengths cut from a rope of suitable thickness, answer all requirements, and are perhaps easier to use than other forms of non-cohesive gold. When large pellets are needed, two or three or more sheets of No. 4 or No. 5 foil may be placed on one another, and then rolled or twisted into a rope, and cut up into pellets, or short lengths, as desired. Some of the details of filling cavities will be considered later.

Annealing Gold.—Annealing can be done either with the naked flame of a spirit-lamp, or by placing the gold on a thin sheet of platinum or mica, and holding it over the flame. The electric annealer, although extremely satisfactory, and theoretically the only perfect annealer, is by no means a necessity, and the statements that have been made, that

its use causes the gold to work with an added degree of softness that enables better and more rapid work to be accomplished, do not agree with the writer's experience. It certainly thoroughly anneals the gold without any fear of over-annealing it. The writer has left both foil and crystal gold on it for half-an-hour with the current full on (Custer's electric annealer), and found the gold worked perfectly satisfactorily. It is only necessary, however, to leave the current on till a part of the fireclay slab glows with the heat, and any one who has regard for his own comfort, or the well-being of his bracket-table, will switch off the current as soon as the requisite heat is produced. These annealers would be greatly improved if they were larger. If a dentist works without an assistant at the chair, or if the assistant is employed in malleting the gold, he will have to stop to recharge the annealer with gold several times during the making of a large gold filling. If the naked flame of a spirit-lamp is used, it must give off no carbon. The least trace of carbon deposited on the gold will prevent perfect cohesion and spoil its working properties.

Methylated spirit seems to vary very much in this respect, and it is well to test it by placing a sheet of mica over the flame, and leaving it there for ten minutes. One lot of methylated spirit will be found

to thoroughly blacken the mica, and another lot will leave it quite clean. The safest thing to do is to use rectified spirits of wine. Absolute alcohol has been recommended, but does not appear to be any better in this connection than rectified spirit, and is more expensive. It is difficult to anneal gold on a sheet of mica; the mica does not become red-hot except at the edges, and the time necessary to hold the mica over the flame can only be guessed at, although some operators, from great experience, seem instinctively to know when the desired effect is produced. The writer made a few experiments in trying to regulate this by timing with the second-hand of a watch, but gave it up in despair. The gold was always either under, or over, annealed. There is no difficulty in using a thin sheet of platinum, for as soon as the platinum glows with the heat, the gold is fully and satisfactorily annealed. It has already been mentioned that skill and experience with the sheet of mica are particularly valuable in the production of semi-cohesive gold.

All gold that is to be used cohesively, whether foil or crystal gold, should be annealed before use. It can be heated to a dull red without injury, and in fact, if the greatest cohesion and hardness of the filling is desired, it is necessary to heat it to this point. The gold will, however, in many cases work

more softly and easily if not so highly annealed, (particularly if in the pellet form) and as something less than full annealing is often desirable in order to secure ease of working and ready adaptability to cavity walls, many operators find it useful to anneal each piece of gold by passing it over or through the flame just before placing it in the cavity, and by this means to vary the cohesiveness as desired. Others, again, will anneal all the gold necessary for an operation before commencing it. Strips of thin tape are almost impossible to anneal evenly in the naked flame unless the following procedure is adopted, which is very satisfactory:—After folding the sheet of gold, cut it into oblong pieces about half an inch wide, and one or two inches long; take hold of one end of this broad, flat piece of gold with foil carriers, and hold it over the flame until it becomes just red hot, then transfer the foil carriers to the other end, and re-anneal it; by this means the part that was originally held by the point of the carriers, and which would consequently be imperfectly heated, is fully annealed, and if anything like reasonable care is taken, the gold is not in any way over-annealed at any part. A great amount of gold may be annealed in this way before the operation is commenced, and will hold its cohesive properties for a considerable time. If, however, the surface of the

filling is approached, and the gold used at this part has been on the pad for some time, it is as well to pass each strip rapidly through the flame just before inserting it. Of course these broad, oblong pieces are cut up into strips after this annealing. It has been stated that this hardens the edges and renders the manipulation difficult and the result uncertain. This is a mistake as far as thin strips are concerned, for cutting them up after annealing makes no difference, either real or apparent. The only difficulty is, that the gold has a tendency to stick to the blades of the scissors ; but this is a small matter, and either passing the blades of the scissors between the fingers, or changing the scissors, will greatly prevent this. The same difficulty exists to some extent in cutting up strips of gold before annealing, and some operators, to avoid it, place the gold between sheets of thin paper and cut through both paper and gold.

Before dismissing the subject of annealing, there are two little points that may be mentioned. One is that Watts' crystal gold, if taken from the freshly opened box, will often work unsatisfactorily if it is fully annealed. Very light annealing is all it must be subjected to, but as soon as it has become stale from exposure it can be brought to a full dull red heat without detriment. This peculiarity may

apply to other makes, and is worth remembering. Another point is, that the thick small squares that have been alluded to for surfacing fillings, can be more satisfactorily annealed on the electric annealer than in any other way.

The balling up of gold that is so often alluded to, simply means that the gold refuses to cohere. This may be due to under, or over, annealing—usually the latter—but given a good make of gold, and an operator of some experience who is careful in little things, it is rarely that a piece of gold will "ball-up." On the other hand, given a careless dentist, whose foil-carriers are smeared with dried varnish or chloropercha, the serrations of whose instruments are rusty or dirty, and who anneals his gold in the naked flame of a spirit-lamp, the wick of which is thoroughly charred, or contaminated with the fumes of the matches used in lighting it, &c., it is not to be wondered at if he finds it difficult to work cohesive gold.

Combination of Cohesive and Non-Cohesive Gold.—Non-cohesive gold is frequently used for starting fillings of cohesive gold, either to facilitate this part of the operation, or to avoid the use of starting pits. The writer has never been able to understand the prejudice that exists in the minds of some against starting pits. A starting pit is drilled

in the dentine at a safe distance between the enamel border and the pulp, its direction being away from the pulp. Any idea that a small pin-like piece of gold—that is more remote from the pulp than the large mass of filling that rests on the floor of the cavity—should cause irritation or death of the pulp, when the filling itself is a far more probable cause of this, is difficult of comprehension. It is true that a pin-head or pin-point gold filling that does not extend more than half a millimetre into the dentine *may* cause death of a pulp; but if these cases were seriously considered, no one would ever make a gold filling.

When it comes, however, to considering the difficulty that may every now and then occur in making a satisfactory starting pit, and when any trouble or time that filling the pit and carefully extending the gold over a cervical wall, or other starting wall, is considered, the value and convenience of wedging in a base of non-cohesive gold is manifest. Cohesive gold does not cohere with non-cohesive, and will not usually even stick to it, consequently a mechanical adhesion, produced by driving or locking the cohesive into the non-cohesive, is imperative. This can be effected with sharp, deeply serrated pluggers; or pits may be forced into the non-cohesive gold (in the direction of the cervico

lingual, and cervico labial, or buccal, angles), and then forcing the cohesive into these pits.

It is important to begin attaching the cohesive gold before the non-cohesive is much condensed. As soon as it is wedged to place, and sufficiently firmly pressed to prevent dislodgment, the cohesive should be applied, and the condensation of the cohesive layer will then fully condense the non-cohesive, and drive it into close contact with the wall.

In an occlusal cavity, or in a small round or oblong approximal cavity that can be filled by force applied at right angles to the floor, a base of non-cohesive may be wedged between the walls, and pressed down on to the floor. The deeply serrated plugger, or the forcing of a few pits into the base, will enable the cohesive gold to be easily added. The making of combined fillings of non-cohesive and cohesive gold presupposes the use of much more non-cohesive gold than is employed for merely starting the filling. This method is resorted to mainly for purposes of convenience and rapidity. In approximo-occlusal cavities of molars and bicuspids, the non-cohesive is used up to the knuckle, and the cohesive completion, or top, is securely locked into the rest of the cavity; no question of mechanical attachment of the cohesive to the non-cohesive portion

being in these cases relied on for *retention* of the cohesive top. In approximal cavities in incisors and canines the cohesive portion depends for its retainage on an interlocking attachment to the non-cohesive gold.

In occlusal cavities an interlocking is also generally resorted to, but the writer considers, generally speaking, that combination fillings in these cases —apart from merely starting the cohesive gold— are unnecessary, and that either cohesive or non-cohesive fillings are better. The method of interlocking cohesive gold into non-cohesive, that is useful in incisors and canines, may, however, be applied to occlusal cases if desired. In approximal cavities in incisors and canines the filling may be made in the usual non-cohesive way, as far as laterally packing the gold and forcing holes in it with the wedge is concerned. Instead, however, of filling up the wedge-made holes with non-cohesive gold, they should be filled with small pieces of cohesive gold. This brings it about that the filling is a non-cohesive one, with a number of rods or nails of cohesive gold thoroughly and deeply driven into it. The ends of these rods will be a number of studs so dotted over the surface that one or more layers of cohesive gold may be readily and securely attached to them, and, especially if

during the procedure the surface of the non-cohesive gold is depressed, an even surface of cohesive gold will be produced. Another method that is useful in incisors and canines is to fill the cavity with non-cohesive gold, and then—instead of making any holes in it with the wedge—to force the mass in the direction of the labial wall in working from the back, and in the direction of the lingual wall if working from the front, in such a way that a sufficiently deep and broad trench-like cavity is formed for the reception of the cohesive portion. The success of this depends on an accurate adaptation of the non-cohesive gold to the cervical, labial or lingual, and cutting edge walls by carefully condensing against these walls as each piece is packed in place, and in giving a retaining shape to the trench that is to be filled with cohesive gold. The engine-bur may be used to cut out some of the non-cohesive gold if necessary. In this method either the lingual or labial wall is left free, and is utilised as a help in retaining the cohesive portion.

In theory, combination fillings of non-cohesive and cohesive golds are inadvisable, because there is a different spring, or resistance, to the stress of mastication in these two kinds of gold, each differing in rigidity or elasticity. In practice it will be found that this combination will in many cases prevent

the wearing of the surface of a non-cohesive plug, and may produce a durable filling in place of a readily worn away or disintegrated one. The writer has a distinct prejudice in favour of an all-cohesive filling, or an all-non-cohesive filling, providing either one is sufficiently perfect to serve its purpose; but he willingly admits that these combination fillings serve a very useful purpose, and are often preferable to any attempt that may be made with either material used singly. He would also beg to suggest that a young dentist, who has not had the time or experience to enable him to become an expert in either the cohesive or the non-cohesive method, may find these combination fillings a very useful bridge at the outset of his career.

Instruments for Filling Teeth with Gold.— The pluggers used for filling teeth with gold are many and various. Such a large number have been designed that it is hard to make a selection. The difficulty is not so much in knowing what to choose, as what to reject, for it is impracticable to regularly use more than a certain number. Those shown in diagram on following page are all useful.

Two or three sizes of point of each instrument may be used, varying from about one thirty-second to one sixty-fourth part of an inch in diameter,

bearing in mind the principles in regard to relationship of plugger-point to form of gold, and force applied, that have been alluded to. A small foot plugger, such as No. 12 of the "Ladmore" set, is valuable; and perhaps the most complete, satisfactory, and adaptable mallet set that has been produced is the "Chappel" set. One or two ball-ended burnishers

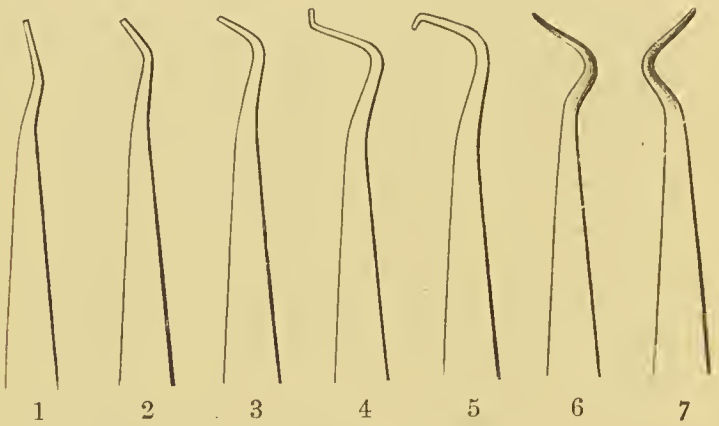

Fig. 2.

for exposed surfaces, and one or two thin flat ones for use between the teeth should be added to one's case of gold-filling instruments.

The pluggers for cohesive gold may be either smooth, or finely serrated. Smooth or non-serrated pluggers may be satisfactorily used, but owing to their greater liability to slip are rather dangerous in the hands of a novice. They are not so likely to damage the margins of a cavity as serrated ones, but

owing to the manner in which fine serrations generally facilitate the work, they are preferred by the majority of operators. The form of the end, or condensing surface, of the plugger makes little or no difference to the excellence of the work. Flat, or convex, or even ball-ended instruments may be used. A rounded end is not so likely to damage margins, and the smooth convex form admits of a sliding blow being used. This is a favourite method with some operators. There is no such thing as the form of the plugger having anything to do with spreading the gold. Spreading only takes place as the result of extreme condensation, and the shape of the instrument has nothing to do with this.

It does not matter if the gold is packed and condensed parallel to the walls, or at right angles to them. Which method is adopted will depend on the exigencies of the case. The gold may perhaps be accurately adapted more easily and rapidly if right-angle condensation is resorted to, but thorough condensation in a parallel direction will produce an equally good result.

Pluggers for packing non-cohesive gold are much of the same forms as those used in the cohesive method. In many cases the points may be larger and the serrations deeper. The wedge-shaped pluggers should taper to an absolutely sharp point.

A four-sided instrument that is tapered down to a point is a useful form, and many of the older operators were in the habit of keeping the point and side angles as sharp as possible by rubbing them on an oil-stone. They often used the sides for packing and condensing the gold laterally, then the point for further lateral condensation, and finally the point for making holes in the filling and for complete consolidation of surface.

Mallets.—It is probable that no better work has ever been acomplished than that which is done by means of the old-fashioned hand mallet. No other percussive instrument enables the dentist to feel so exactly what he is doing, and to vary the force so accurately and delicately. In order to use the hand mallet with ease and precision the operator must be completely ambidextrous, or else be dependent on a skilled assistant. Very few dentists are ambidextrous, and even if the operator is equally skilled in the use of both hands, an assistant is often necessary in order to hold back the cheeks of a patient, and to throw light into the cavity with the mouth mirror. The hand mallet will, therefore, never be generally adopted, more especially as some very efficient substitutes have been invented. The steel hand mallet gives a sharp, ringing blow, and appears to condense the gold more quickly than the lead

mallet. The lead mallet seems to demand a little longer use before the feeling of perfect condensation is arrived at. The sharp blow of the steel mallet is, however, more disagreeable to a patient than the dull, dead blow of the lead mallet.

These mallets are also made of brass, tin, and composition metals. These, however, are either akin to the steel, or the lead mallet, depending on the kind of metal used, and there does not seem to be any particular advantage in attempting a compromise between the sharp blow of the steel, and the dull blow of the lead mallet. The improved automatic mallets (of which the old Shaw and Lewis mallet is the progenitor) are very efficient instruments, and their convenience and little liability to get out of order make them very popular.

Certain dentists have found that the automatic mallet is disagreeable to patients, because there is a distinct interval between the placing of the plugger on the gold, and the delivery of the blow. It must not be forgotten that there are several makes of automatic mallets which vary somewhat in their construction and working properties. Any appreciable interval or hiatus between placing the plugger on the gold and delivering the blow, is due either to using an automatic mallet that is not of the best construction, or to screwing it up to a very heavy

blow. The best manner of adjusting the blow will also, no doubt, vary in different mallets. The writer finds as the result of testing fillings (made out of the mouth), for cohesion, that with the automatic mallet he prefers to use, a long stroke and a light blow give better results than a short stroke and a heavy blow; and for ease of manipulation, comfort of the patient, and general efficiency, he has adopted a medium or light medium blow, and an adjustment of the length of stroke or blow that is exactly midway between the longest and shortest adjustments. He also finds, as the result of trying them on his own teeth, that an automatic mallet is the least disagreeable of all the mallets he has used. The various dental engine and electric mallets are much liked by some operators, and the use of suspension electric dental engines enables the engine mallets to be used with the greatest convenienee. The writer finds that these fast-striking mallets greatly interfere with the sense of touch, and it is consequently difficult to know exactly when the gold is condensed. He also finds that the blow of some of these instruments is so indistinct (more a vibration than a blow), that it is necessary either to use them with great pressure—which is disagreeable to the patient—or else spend a very long time in condensing each layer of gold. These instruments, however, vary in their

working properties, depending on the kind that is used, and great familiarity with an instrument has much to do with the quality of the work produced. The nearest approach to the hand mallet is a certain make of pneumatic mallet. If it is so constructed that the plugger is screwed into the hand-piece, so that they form one rigid plugger, and the plunger strikes the end of the hand-piece above the part that is grasped by the hand, the operator feels exactly what he is doing, and can regulate and vary the force of the impact far better than when he has to hold a hand-piece inside which the plunger works.

Preparation of Cavities for Gold Fillings.—To prepare a cavity for the reception of gold it is necessary, in nearly all cases, to cut away part of the tooth, to enable the instruments to be freely used in the removal of the decay, the cutting of the retainage, and the insertion and packing of the gold.

A certain amount of "opening the cavity," as it is called, is necessary, no matter what material is selected; but the cutting must usually be much more freely done if gold is to be used, for every piece must be placed at once just where it is wanted, and condensed by the direct action of the plugger. There is no possibility of pressing the gold round a corner and squeezing it into position. This cutting away of part of the tooth does no

harm. The part removed is replaced with gold, and it can be done in such a manner that the tooth is in no way weakened, or in any way made less useful. To open an occlusal cavity the overhanging edges of enamel are cut away until they are level with the interior walls. It must be remembered that, owing to the body of a tooth being composed of dentine, it usually decays to a greater

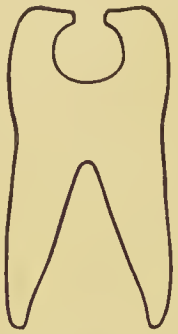

FIG. 3*a*.

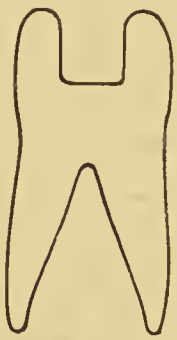

FIG. 3*b*.

extent than the enamel, and on the removal of the decay the interior is consequently larger or more hollowed out than the orifice (Fig. 3*a*). The rule in occlusal cavities is to make the orifice as large as the interior diameter, so as to do away with any overhanging ledge under which it would be almost impossible to accurately pack and condense the gold (Fig. 3*b*). This applies also to cavities on the labial, buccal, and lingual surfaces of the teeth, and to a certain extent to all cavities.

To open a mesial or distal cavity in the six upper front teeth, it is usually advantageous to cut away either part or the whole of the lingual wall. Occasionally part of the labial wall may be removed instead, but this should, as a rule, be avoided, for although it makes the whole operation easier, and it can be completed in less time, the gold shows somewhat, and this should always be prevented if possible. Some operators, instead of cutting away either the lingual or labial wall, separate the teeth widely by pressure; and beyond trimming the edges to obtain smooth, firm margins, do not remove any of the walls for the purpose of obtaining access.

The writer having originally practised this wide separation method with as much preservation of both lateral walls as possible, infinitely prefers a slight separation and the access obtained by cutting away one of the lateral walls. The packing of the gold can be accomplished with greater certainty, the nuisance of obtaining a wide separation is avoided, the patient is not worried with keeping the cotton-wool or tape, or whatever may be used to obtain the desired space, between the teeth for a considerable time, the teeth rarely become painful from the pressure, and the cutting secures free margins at parts of the filling at any rate. It is advisable, however, to obtain a slight separation by pressure, so as to admit

of the gold being accurately carried over all margins, and to admit of the trimming and polishing tapes and discs being easily applied. This space can be obtained immediately, if desired, by pressing a wedge of wood between the teeth, or by cutting with a thin separating file. If the separating file is used, the slight division thus made will not spoil the appearance of the teeth, and is decidedly preferable to showing a line of gold; but except for preventing the exposure of gold, it is well to remove no more of a labial wall than is absolutely necessary, and as a rule slight separation by pressure is better than slight separation with a file.

To obtain access to all medium and large-sized cavities on the approximal surfaces of bicuspids and molars, the overhanging enamel at the occlusal part is entirely cut away, and if necessary—particularly in distal cavities—part of the buccal wall may also be removed. In all medium and large-sized cavities the lateral walls should, if possible, be cut away sufficiently to secure free margins, but more than the cutting necessary for this purpose is admissible in certain distal cavities where the access is difficult.

Having opened the cavity, the next step is the removal of the decay. This is easily accomplished (unless very sensitive) by the use of sharp spoon

and hatchet excavators of various sizes and curves. Now, with the exception of the labial walls of front teeth, break down all frail overhanging enamel at all parts, and be particularly thorough in this respect at cervical walls. (Cavities that are to be filled with gold are alluded to, not frail shells that can only be filled with soft plastics.) This can usually be easily done by placing a suitable spoon excavator at the edge just outside the cavity, and breaking it down by inward pressure (pressure in the direction of the cavity). The plug-trimming files (Smith's discs and Rhein's trimmers) are also useful for supplementing the spoon excavators, and for trimming margins generally. Chisels and sharp engine-burs should be used for removing overhanging enamel in occlusal cavities, and for freeing and trimming the lateral walls of approximal cavities. In approximo-occlusal cavities in bicuspids and molars a good deal of overhanging enamel can often be removed in a rapid manner by means of a chisel and hand mallet. In suitable cases a very light tap, which causes the patient no pain or even inconvenience, is all that is necessary, providing, of course, the chisel is held at the proper angle, viz. in the line of cleavage of the enamel rods. Margins of cavities should usually be bevelled if gold is to be used. The extent of the bevelling will depend on the case, and the manner in

which it will facilitate the carrying of the gold over the margins without damaging them. The greater the bevel, the more difficult it is to finish to a fine clean edge, and the labial margins of front teeth and the margins of labial cavities in general, admit of very little bevelling if the finest blending of tooth-structure and gold is necessary for appearance' sake. The thickness of the gold over the bevelled margin must also be considered, for it is quite possible to bevel to such an extent that a thin layer of gold over a much-bevelled margin becomes lifted up in time through the stress of mastication, and an imperfect joint results. The main thing to consider is to produce a margin that will not be chipped or broken by the force used in condensing the gold over it, and which is sufficiently cleanly cut to admit of a fine margin when the gold is finished. Having removed decay and trimmed the margins, proceed to shape the cavity for retainage. (The final finishing or smoothing of the margins should be done just before the insertion of the gold.)

Retainage.—The retainage of a filling depends on the shaping of the interior of the cavity, and in this connection there are several points that demand careful consideration. The retainage should be made in such a manner that the tooth is weakened as little as possible; the pulp is not unduly ap-

proached; and the accurate condensation of the filling at all parts is not interfered with. All retainage must be made in accessible places. It is no use making an accessible part of a cavity either inaccessible or difficult of access by undercutting, and it must not be forgotten that to make an undercut takes up time and often causes pain, and that to fill the undercut also takes time. It may therefore be laid down that it is distinctly advisable to make retainage in places that are easily reached and can be readily and accurately filled, and that no more undercutting should be done than is absolutely necessary. The operator must, however, be guided by the circumstances of each case, and when necessary, time and convenience must be sacrificed to stability. As an illustration of this, the writer once saw a celebrated dentist, who was renowned for the rapidity with which he could insert gold fillings, demonstrate his method. The skill and manipulative dexterity of this operator was of a very high order, but he so hollowed out the cavity in order to easily and rapidly insert the gold, that it was not surprising to learn that the filling shortly afterwards remained in a perfect state of preservation in the waistcoat pocket of the patient. If this cavity had been prepared with every respect for maintenance of strength of tooth

structure, it would have taken far longer to insert the gold, but the filling would have proved more useful.

The question of shaping cavities for retention, may be divided into a consideration of the older or more general method, and the newer proceeding perfected and introduced by Dr. Black. In the older method the cervical walls are curved or rounded, and retainage as well as maintenance of integrity, or absence of rocking of the gold during its condensation, is effected by means of pits, grooves, and undercuts. Dr. Black's method consists in broad, flat cervical walls; cavity walls at right angles to the floor; the formation of sharp angles at the lines of junction of the walls and the floor, and the absence of all pits, grooves, or undercuts. There is no doubt that Dr. Black's method is based on sound mechanical or engineering principles, and that it facilitates the introduction and packing of the gold in many cases, enabling the filling to be made more rapidly. An operator cannot, however, always do exactly what he would like to do. There is not always as much tooth structure left to work upon as is desirable, and patients are not all blocks of wood who will permit their teeth to be excavated on exact mathematical lines. It is often necessary to compromise, and whenever this can be done

without any real detriment to the operation, it is advisable to do so. It may also be pointed out that no better work has ever been done, or in all probability ever will be done with gold, than that accomplished by the late Dr. Webb and several others who prepared cavities in the older way. It is more difficult to prepare cavities in the new manner, and the inverted cone bur, which plays such a large part in this preparation, is a much more dangerous instrument than the round bur. Those who practise the new method exclusively are doubtless sufficiently expert in it to be unaware of its ever presenting difficulties. The writer desires to express his appreciation and admiration of this method, but cannot help thinking that it has sometimes been presented with too little regard for, and too great depreciation of, the older way.

In preparing cavities on occlusal surfaces of molars and bicuspids, both the old and new methods are practically "on all fours." A flat floor and straight walls at right angles to the floor, is the preparation that is necessary, whether it takes the form of an ordinary round, or oblong cavity, or the cutting-out of fissures. To effect this, all overhanging enamel is cut away until the softened dentine is removed, and the cavity generally shaped up, always cutting until hard dentine is reached. The floor is flattened,

and the angles made sharp with an inverted cone bur, or suitable excavator, and this bur can be used in these cavities easily and with safety.

In incisors and canines the older method is to remove the decay, and cut to hard dentine with excavators and round burs. A groove is then cut along the cervical wall with a small round bur, taking care to avoid, on the one hand, cutting too close to the enamel margin, and, on the other, too close to the pulp. The ends of the groove are then deepened slightly, by drilling upwards and outwards at the cervico-labial, and upwards and backwards at the cervico-palatal parts. One or both of these depressions is deepened into a starting pit, if desired. An opposing retainage is made by drilling a little pit in the dentine at the cutting edge whenever the cavity will admit of this being done without weakening the cutting edge; and whenever the labial and palatal walls will admit of it, a fine groove is made along them with a fine round bur, or an excavator, at the line of junction of these walls and the floor of the cavity. Whenever, as often happens, the enamel is not supported with a sufficient thickness of dentine to admit of this, the cervical retainage is deepened and broadened, particularly at the ends of the cervical groove; and whenever the near approach of the cavity to the cutting edge renders the drilling of a

pit at this part out of the question, a mere cutting of this wall at right angles to the floor is all that can be done. In many cases, where, owing to breaking down, or frailty, of the lateral walls, the retainage is rendered doubtful, the cervical cutting may be supplemented by extending the cavity well across the lingual surface, and slightly undercutting the dentine at this part. By this extension a frail or shallow lingual wall may be converted into a strong and most useful one. Care must be taken in doing this, and the extension had better be broad and shallow, rather than narrow and deep, so as to avoid cutting too near the pulp.

Dr. Black's method in these cavities, is to cut the cervical wall flat at right angles to the floor, and to extend it in the region of the cervico-labial and cervico-lingual angles as far as practicable. The cutting edge of the cavity is made at right angles to the floor, and the labial wall is also cut at right angles to the floor. The lingual wall is squared out in the same way, wherever its thickness will admit of this being done. This generally means a squaring out at the cervical portion of this wall, and, if practicable, a little squaring out near the cutting edge. When the cavity involves the cutting edge of the tooth, or approaches it so closely that a break may

occur in this part after filling, a step extension is cut across the cutting edge.

Access to these cavities is obtained by separation, and by cutting away part of either the labial or the lingual wall. The methods of access apply equally well to all methods of preparation. Small round or oblong cavities are prepared in a similar way by either the old or the new method, straight walls and a flat floor being usually readily obtained; and the formation of sharp angles, or in the older method, the making of a little groove around the cavity, is readily accomplished with an inverted cone bur or suitable excavator.

In cavities on the approximal sides of bicuspids and molars, it is usually necessary to convert them into approximo-occlusal cavities, if gold is to be satisfactorily used. This is effected by cutting away the overhanging enamel and dentine at the occlusal part, and making the cavity into one of three walls. In the older method the absence of the occlusal wall was counterbalanced by cutting a distinct groove, about one sixty-fourth of an inch deep, along the palatal and buccal walls, at the line of junction with the floor, extending from the occlusal enamel to the cervical wall; and if the lateral walls were also slightly convex, or sloping inwards, the retainage was considered sufficient. The cervical margin was

left curved, but was not grooved, as the proximity of the pulp would render this a dangerous proceeding, unless the groove was made too close to the enamel border, leading to its being damaged by condensation of the gold. The lateral grooves were generally deepened into little pits at the cervical wall, and further deepened—if thought good—into starting pits. These depressions, supplemented by the lateral grooves, effectually prevented rocking or displacement of the gold during its manipulation. Many operators found it necessary to produce a fourth wall in these cavities by undercutting the occlusal part, and this could generally be accomplished without this margin being afterwards broken or chipped by the force of mastication; and this undercutting was often made easier by a dipping in of the decay at this part.

It frequently happens, however, that the lateral walls are frail, and will admit of little or no retainage being made at this part, and they may even slope slightly outwards. In these cases such undercutting at the cervico-buccal and cervico-lingual angles, as might be necessary to start the filling, and prevent its rocking, was resorted to, as well as cutting the juncture of the lateral walls and floor of the cavity into as distinct angles as possible. The cavity was then extended sufficiently across the

occlusal surface to produce a step, or arm-like extension, sufficiently broad and deep to counterbalance the want of retention that would otherwise have existed. Many operators adopted this step extension as a general method of practice to prevent weakening the lateral walls by grooving or otherwise undercutting them, and to save the time, trouble, and uncertainty of filling these lateral grooves or undercuts. With the exception that the rounded or curved cervical wall was retained, and that depressions were made at either side of this wall, and that the end of the step was often undercut, it will be seen that this is a near approach to the Black method.

Dr. Black's method is to make a broad, flat, well-laterally-extended cervical wall; to make the lateral walls parallel to the floor; to cut the line of junction of these walls and the floor into sharp angles; to cut the step extension in every case, and to make it with straight walls, a flat floor, and sharp angles, and to square out, or make as distinct as possible, the angles at the juncture of the lateral and cervical walls. Theoretically, all methods of bicuspid and molar preparations of approximo-occlusal cavities weaken the walls, and may lead to a breakdown. Any grooving or undercutting of the lateral walls may do this; and even if this is

avoided, a step extension, which, owing to the presence of two approximo-occlusal fillings in the same tooth, necessarily forms a trench-like cutting right across the occlusal surface, may, by thus weakening the cusps, cause a very extensive break to occur. For this reason some operators deprecate the step, and, while following out Dr. Black's directions at other parts of the cavity, prefer to slightly undercut the occlusal part, but avoid altogether the step extension.

In practice, however, it will be found that accidents of this kind rarely occur with any kind of preparation—providing it is carefully carried out—and that if an accident occurs it is generally due to the filling of a frail tooth. Accidents of this kind may often be prevented by shortening and rounding the cusps of the filled tooth, and also the cusps of the opposing tooth or teeth. This is a proceeding that should always be considered, and practised, whenever the circumstances of the case present the possibility of an accident occurring.

A careful preparation of the margin is imperative. All little cracks, chalky patches, or defects must be cut out; and it is advisable to carefully examine the enamel in the neighbourhood of the margin with a magnifying glass. Many fillings fail because of some small defect in the enamel, close to,

but not immediately connected with the margin. The margin should be made as smooth as possible with chisels, spoon excavators, fine-cut engine-burs, fine files, emery or sandpaper tapes or discs, &c., whichever may be most suitable to the case in hand.

The introduction of the small stones known as "Gem Cavity Trimmers" renders the proper preparation of margins in many cases easy and certain. Care must be taken in using these stones, for if they catch or become jammed between the teeth ever so slightly the stone will be broken; otherwise they are fairly durable.

Extension for Prevention.—What is known as extension for prevention has provoked much discussion. This method of preparing cavities consists in cutting the cervical margins of approximal cavities well below the gum, and cutting away the lateral walls, until the junction of the filling and the margins of the cavity is sufficiently exposed to be kept clean, and free from food deposits, by the action of the tongue, lips, and cheeks, and the toothbrush. The cervical margin is protected by the gum, and it may be conceded that if the margins of a well-made and well-extended gold filling are attacked by decay, it is due to carelessness on the part of the patient in keeping the teeth clean. It is very nice to be able to say to a patient, "Your teeth are now restored in

such a manner that their permanent prescrvation is entirely in your own hands;" but it is no more possible to carry out this method to the complete satisfaction of both operator and patient in every case, or in the majority of cases, than it is possible to fill every cavity with gold with complete satisfaction to all parties. Extension for prevention is more necessary in the bicuspid and molar region, than in the incisors and cuspids, for the simple reason that the margins of non-extended cavities—meaning such as are only extended for access as opposed to prevention—in front teeth are not so prone to decay, and because extension for prevention in front teeth may destroy their appearance. It should also be remembered that the proper extending of a cavity in an incisor or cuspid, as well as in other positions, prolongs the pain of the operation, and unless this extending is absolutely necessary, it is unwise to push the endurance of a good patient to an extreme.

Non-extended cavities in the front teeth, if well filled with gold, usually last sufficiently long to induce an operator to content himself with merely extension for access. The comparatively frcquent failure of gold fillings in approximal cavities in bicuspids and molars that are not extended for prevention, makes the question of whether it is worth while to use gold entirely

in these cases depend to a great extent on the production or the non-production of extension for prevention. If it is admitted that non-extended gold fillings frequently fail in a comparatively short time in these places, and extension cannot be properly carried out, it is surely hardly wise to use the material that demands the greatest skill, time, energy, and mental and physical strain to insert. If the filling is likely to fail owing to non-extension, it had better be one that is more easily introduced. If possible let it be one that is supposed, at any rate, to have a preservative effect on the tooth, unless the appearance of the tooth demands the use of gold. An amalgam filling, with or without a cement lining, and with or without a gold top or masticating surface, as the kind of amalgam used and the circumstances of the case suggest, will usually be a more practical and satisfactory operation—all things considered—than any attempt to make an all-gold filling in these cases. Extension for prevention as an "academic principle" is perfectly sound, but the writer all through these notes has endeavoured to point out that "circumstances alter cases."

Insertion of Gold.—To explain methods of packing gold into teeth, a few typical cases will be mentioned. It does not come within the scope of this

work to minutely describe the filling of numbers of cavities in all sorts of positions, each of which may present instructive peculiarities. It is intended merely to allude to the filling of certain cavities; for it is presumed that an operator who has once grasped general principles will be able to modify them as circumstances may demand.

Cohesive Gold.—To fill a very small occlusal cavity, or a very small cavity in any exposed position, take a small pellet of gold, and simply press or hammer it in. A cavity of this size may be considered as similar to a starting pit, and filled accordingly. Pack in other very small pellets one by one, attaching them to the previously condensed gold until the cavity is full. To fill a cavity a little larger than this, press in a larger pellet of non-cohesive gold, and hold it down, if necessary, with an instrument held in the left hand, until it is packed just sufficiently to stay in place without rocking. If this is not accomplished, remove the pellet and insert another one, pressing it to one side of the cavity, and insert and wedge in other pellets between the first one and the other walls of the cavity, until a sufficient mass has been introduced to stay firmly in place, when the whole of this gold is pressed directly on to the floor. By the use of two instruments, one to hold the gold and the other to

partially condense it, there is usually no difficulty in making the foundation, and the filling is then completed with pellets or tapes, the first one or more of which are driven in and attached to the non-cohesive base as already described. To fill a star-shaped cavity, consisting of a central hole, with fissure-like extensions, wedge non-cohesive pellets towards the ends of each arm, until the centre is reached; then wedge more pellets in the centre, condense down sufficiently to admit of the attachment of cohesive gold, and build up with pellets or strips. If the extension arms and the centre are too shallow to admit of this method of wedging a foundation being satisfactorily carried out, drill a starting pit at the end of each extension, and work the gold from these pits carefully over the whole of the floor, and up to the surface. Fissures must be cut of sufficient depth, and properly squared out to admit of the gold remaining firmly in place, without any lifting of the edges by the force of mastication.

Filling Upper Incisors and Cuspids.—In working from the lingual surface, place a pellet of non-cohesive gold against the cervical wall, and press it well into the angles or undercuts. If one sufficiently large pellet will not stay in place, press a pellet against the cervico-labial angle, another one against the cervico-lingual angle, and then wedge a

third one between these two, and press the whole mass of gold up to the cervical wall. Force a fine-pointed plugger into the gold at one angle of the cervical wall, and fill in with small pieces of cohesive gold. Pack the non-cohesive gold well into the angle or undercut, and add cohesive gold while doing so. Treat the other angle in the same way. This locks the non-cohesive gold firmly in place, and provides a ready and firm attachment for more cohesive gold, which can then be easily extended from one angle to the other, driving the non-cohesive base into close contact with the wall as the condensation of the cohesive layer is carried out. In order to drive the gold accurately into sharp or well-defined angles, a very fine-pointed plugger or, better still, one with a flattened almost knife-like edge, with fine single serrations cut on the edge, is needed. The manner in which a cavity is prepared, and the sharpness of the angles will determine the kind of plugger to be used at these parts. If a starting pit is used, it should be drilled at the cervico-labial angle, and carefully filled with cohesive gold; the foundation is then made by carefully working the gold across the cervical wall from the starting pit, until it reaches, and can be packed into, the cervico-lingual angle or undercut. In making a starting pit, it should only be deep enough to readily and securely

hold the first few pieces of gold, and should be only of sufficient diameter to easily admit the insertion and withdrawal of the fine plugger. There is no advantage in undercutting a starting pit, although squaring out or flattening the bottom is occasionally useful. It is, on the contrary, advantageous to enlarge its orifice somewhat, so as to enable the rest of the gold to be more easily attached. As soon as the foundation is made, the filling is continued by adding more gold at the cervico-labial angle, taking special care to thoroughly condense it at the labial wall; more gold is then worked across to the lingual wall, and carefully condensed against it, the direction of force being mainly in the direction of the cervical wall. As the filling proceeds in this way, it is useful to turn the overlap over the labial wall with a thin, flat burnisher, and to firmly press or rub it against the margin.

The cervical margin should also have been treated in this way. The surface of the filling is then further condensed, and built up by adding gold to it if necessary, applying the force at right angles, or somewhat at right angles, to the surface. As the filling is built downwards in the direction of the cutting edge, it becomes impossible to apply the force in the direction of the cervical wall with

advantage. Right-angle force applied directly to the labial wall, the cutting edge, and the floor of the cavity, is now resorted to, still continuing to turn the gold over the labial wall. Obtuse-angle, right-angle, and corkscrew pluggers will all be found useful at these parts, and hand pressure will be found needful in very many of these cavities that are opened into, and filled from, the lingual surface. Working by reflection in the mouth mirror is usually a convenience, and often a necessity, in these cases. It is also frequently a convenience to force a pellet of non-cohesive gold into the angle or pit at the cutting edge, and this often secures a better adaptation at the bottom of the angle or pit. In filling these cavities from the labial surface, the method of procedure is very similar, except that if a starting pit is used, it should be drilled at the cervico-lingual angle, and the foundation worked across to the cervico-labial angle. The labial wall becomes what the lingual wall was when filling from the back, and *vice versâ*, and the preparation of the cavity, and the packing of the gold, is regulated accordingly. A mallet can generally be easily and accurately used from the labial surface, and the force applied in any direction, as the exigencies of the case demand. The careful turning over of the gold will take place at the lingual instead of at the labial wall. Unless a very wide

separation has been secured, or unless both the lateral walls are freely cut away, it is usually impossible to perfect these margins (labial if working from the back, and lingual if working from the front) after the filling is made; and as slight imperfections are often observable, particularly if the teeth are only sufficiently separated to admit of a polishing tape or sandpaper disc, there is every advantage in securing perfection at this part as the work proceeds, and the thin flat burnisher is a convenient and efficient means of securing this.

It has been pointed out that conspicuous gold filling should be avoided as much as possible, and the removal of part of a labial wall to facilitate the operation has been deprecated, notwithstanding that filling from the back frequently demands hand pressure. The removal of part of a labial wall on a distal surface does not, however, render the filling nearly so conspicuous as if the same amount, or even less, had been cut from a mesial surface. This is a point worth considering in selecting the opening, but it is better to get into the habit of filling all these cavities from the back whenever it is possible to do so, although it is more difficult and takes up more time.

Small round or oblong cavities that are surrounded by strong walls, can be filled as if they

were occlusal cavities, for by means of a little extension towards the lingual surface (or the labial surface if necessary) plus a little separation, they can usually be prepared like occlusal cavities, and filled much in the same way, using, of course, instruments sufficiently curved to reach them easily. The first few pellets will generally be packed in the direction of the labial or lingual wall—depending on the opening.

Where both the labial and lingual walls of a cavity are badly broken down, there is usually plenty of room to work the gold partly from the front, and partly from the back. It is impossible to prevent the gold from showing, and cutting for access can usually be freely done. In these cases the gold must first be packed into as deep retainage, or as broad retainage, as can safely be made at the cervical wall, and a thick layer of gold made at this part. It is then carried downwards over the floor and to the cutting edge, and the contour built up by working directly on to this mass. It is important in these cases for the gold to be thoroughly cohesive, and worked with great care and solidity into whatever grooves, undercuts, or angles, can with safety be made at the sides and cutting edge.

Molars and Bicuspids (approximo-occlusal cavities). —To fill an approximal cavity in a molar or

bicuspid opened through the occlusal surface, as already described, a pellet of non-cohesive gold may be placed in the angle formed by the juncture of the cervical and one of the lateral walls, first making a little undercut to deepen this angle if necessary. Another pellet is then placed in the opposing angle, and a third one wedged between

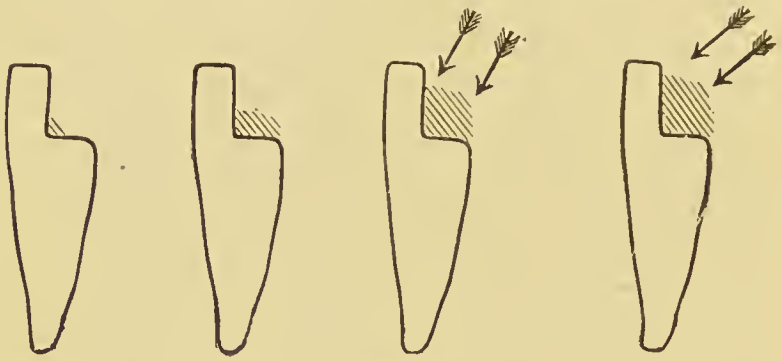

FIG. 4. FIG. 5. FIG. 6. FIG. 7.

The above sketches are not intended to be actual representations of teeth during the process of filling. They are merely diagrams to illustrate the text. The arrows show the directions of force in building the gold.

them, or a large pellet may be placed directly against the cervical wall, and held in place with an instrument in the left hand, and condensed into the angles with a fine-pointed plugger, or while still holding the first pellet in place, smaller ones may be wedged between it and the lateral walls, and into the angles on both sides. Cohesive gold is then attached to the non-cohesive, and the foundation is well con-

densed and made solid at all parts, working the gold principally towards the angle formed by the cervical wall and the floor (Figs. 4 and 5). It is important for the gold to be worked in this manner, for if it should extend in a thin layer over the margin, it will be apt to curl up, or be drawn away during the subsequent manipulation, and either a slight space or a depression left at this part, causing, in all probability, failure of the filling. When the cervical margin is thickly covered and the gold well wrapped over it, the filling is built up, towards the occlusal surface, preferably with a small foot plugger if thin tape is used, in such a manner that the gold is worked with the point or toe well against the walls, and into any grooves or angles that may have been made here, and then by placing the heel of the plugger in the cavity, and the toe outwards, work the gold carefully up to and over the edges, and build up the external surface convex, so as to restore contour, thoroughly consolidating the gold, including the surface, as the work proceeds (Figs. 6 and 7). If there is any difficulty in wrapping the gold over the margins, use for this purpose a hand plugger with a broad condensing surface (Figs. 8 and 9). When the filling reaches the occlusal surface, carry it well across the floor of the occlusal step cavity, build up the back wall of the step, and complete the

filling by working back to the approximal surface. In cases where it is difficult or impossible to start the filling at the cervical wall without undue or undesirable undercutting, one may commence at the occlusal step or undercut, and when this part is sufficiently filled to produce stability of the gold, it may be worked along one of the lateral walls, or over the approximal floor, until the cervical wall is reached and well covered, then the filling may be worked back again towards the occlusal surface until completed. If desired, a starting pit can be made at one or both of the cervical angles, and the filling commenced with cohesive gold, gradually working from one angle to the other, across the cervical wall, until a firm foundation is made.

Fig. 8.

Fig. 9.

In posterior cavities the use of hand pressure and fine points, and working by reflection in the mouth mirror, is often a necessary proceeding.

Restoring Exact Contour in Bicuspids and Molars without Previous Separation.—Unless the teeth have fallen towards one another, owing to destruction of the knuckle by extensive decay, the writer finds that whenever the teeth are fairly regularly placed in the arch, any previous separation of molars and

bicuspids renders the exact restoration of contour difficult and uncertain. In some cases the space secured leads to too great cutting away of the gold, and the all-unsuspected leaving of a permanent space between the teeth. On the other hand, a plus contour may be left which is not only undesirable, but may cause pain through the production of lateral pressure. The following procedure has therefore been adopted with satisfactory results :—

As soon as the cervical margin is well covered with gold, a thin flat burnisher is used to press the overlap on to the root, slightly beyond the margin, and the gold is firmly burnished at this part. The next layers are condensed well on to this gold margin and rubbed over it, and also over the lateral walls. By proceeding in this manner, and carefully and thoroughly rubbing the overlap down on to the exterior surface of the already condensed gold, and over the margin, it is found that the filling gradually swells out to exact contour with little or no surplus to be afterwards removed. As soon as the knuckle is reached, or nearly reached, the gold is well up against the next tooth, and it takes a little force to press the burnisher between the filling and the adjacent tooth in order to wrap down the gold. In a little time, notwithstanding that the burnisher has forced the teeth somewhat

apart, it will be found impossible to press the burnisher between them. Where this happens, the filling is packed against the adjacent tooth somewhat as if it were a matrix, and the filling is completed. The occlusal part is trimmed with plug finishing-burs, and the corners rounded with sandpaper discs. The lateral and cervical edges are firmly burnished, and trimmed with the Rhein plug-trimmers. The lateral margins may also be trimmed if sufficiently exposed with sandpaper discs. A fine ribbon saw is then passed between the teeth, and a fine polishing strip is forced between them through the space made by the saw, and as soon as it slips into the interproximal space, it is freely drawn backwards and forwards in order to perfect the surface of the filling. It may be necessary to soap the polishing strip in order to force it between the teeth. More strips are used until the smoothing is completed, and orange-wood sticks, trimmed to fine flat wedge-shaped ends, may also be passed laterally into the interproximal space, to perfect any depression at the cervical margins that are not reached with the strips. Finally the burnisher may or may not be applied, as thought good. It is found that the teeth are slightly forced apart by the burnisher, during the process of turning down the overlap

at the knuckle, and that the small space made by the saw and the polishing tapes merely enables the teeth to drop back again into their normal positions, and teeth filled in this manner are as closely knuckled up a day or two after the operation as any other teeth in the mouth. It is very nice to be able to separate these teeth so widely that the whole of the surface of the filling can be clearly seen during the trimming and polishing. It is very convenient to be able to build out to such an extent that free use may be made of sandpaper and cuttle-fish discs in trimming and smoothing the filling, and the production of a perfectly smooth, polished, mirror-like surface, that will not reveal even a hair-like scratch under magnifying-glass examination, is the highest expression of dental art and excellence; but when the various difficulties that militate against the accomplishment of this result are considered, and the risk of producing either insufficient or plus contour is realised, it becomes a question whether the filling of bicuspids and molars, without previous separation, is not, as a general rule, the more practical and useful method.

Filling Teeth with Non-Cohesive Gold.—In filling medium or large-sized occlusal cavities in bicuspids and molars, and also on buccal or labial surfaces,

or in any exposed position, a pellet or cylinder is placed against one of the walls, in such a manner that one end of the pellet touches the floor, and the other end projects slightly beyond the orifice. The pellet is then pressed fairly firmly against the wall, and should usually be as large as can be conveniently introduced and pressed into place. Another pellet is placed against one of the other walls, and so on, until the walls are covered with gold, each piece of which has been well pressed laterally to place. Other pellets are in like manner introduced and pressed towards the walls, until only a small hole is left at the centre of the filling; one or more pellets are then forced into this hole, taking care that the gold goes well down to the bottom of the hole, and also taking care that the pellet, if a single one is used, will fill up the hole, or the last one, if more than one is used, will completely fill it when pressed in and condensed as much as possible. It should be mentioned that if more than one pellet is used at this part, the hole should be sufficiently deep to admit of the last pellet being sufficiently deeply inserted to remain in place after the filling is completed and finished. When this hole in the centre is filled up, proceed to make a hole in another part of the plug with the sharp-pointed wedge-shaped plugger, enlarge this hole by lateral pressure,

and fill it up by introducing pellets—if the hole is fairly large—with lateral force until a sufficiently small hole is left to be filled with direct pressure. Continue to make holes in the plug, and fill them up, until the sharp-pointed plugger will make no impression on the surface at any part. Then firmly burnish the surface of the gold, and grind it down to a smooth surface with fine edges. Again burnish thoroughly, and either leave the filling burnished, or finally perfect it with wooden or leather wheels or buffs and a suitable powder, such as fine pumice-stone or Hindostan stone. Cylinders are used exactly like pellets, and strips are folded and pressed flat against the walls, layer by layer, in such a manner that one end of each fold touches the floor, and the other one extends slightly beyond the orifice. Theoretically the cylinder or the strip produces the best filling, because the layers of gold are exactly parallel to the side walls, and as the wear of mastication comes on the ends of the layers of gold, there is little chance of their flaking off. In practice it will be found that pellets cut from a rope of gold serve their purpose extremely well, and the layers are sufficiently parallel for practical purposes; and even the irregular distribution of the gold, produced by tearing pieces from a sheet and rolling them up into balls, can be to a great extent

counteracted by the lateral use of the point, as well as the sides of the wedge, and what may be called a mechanical cohesion of the surface produced by the great compressing power of the absolute point.

It is often a great convenience to use short lengths, or oblong pellets, cut from a rope. One end of the short length is placed against the floor and pressed up to a side wall. The protruding end is then folded over and carried down to the floor, and laterally packed, leaving the doubled end or loop-like projection protruding slightly beyond the orifice. Each pellet or piece is thus folded once on itself. In filling approximal cavities in incisors and canines the gold is first packed against the cervical wall, and more pellets are introduced and pressed in the direction of the cervical wall, taking care the gold is worked firmly against the lateral walls until the cutting edge is nearly reached. One or more pellets are then packed against this wall, until a small space, or hole, only remains to be filled up between the cutting edge of the gold and the rest of the filling. Fill up this space, by directly driving a pellet into it of sufficient size to completely fill it up when well condensed. Then proceed to make holes in the plug, and fill them up as already described. The presence of the adjacent tooth usually renders the labial part of the plug (in working from the back) difficult to easily

reach at this part of the operation, and this illustrates the value of condensing the gold as thoroughly as possible against the labial wall during its introduction. The first few holes made with the wedge should be as close to the labial wall as it is possible to make them, and as a right-angle application of the wedge can rarely be made close to this wall, it loses some of its spreading power at this part, and just in proportion as the form, strength, and accessibility of these cavities preclude the even and complete consolidation of the gold, so will the desirability of using either cohesive gold, or a combination of cohesive and non-cohesive gold, be appreciated, although, of course, great skill in the manipulation of non-cohesive gold will increase the range of its applicability.

In approximo-occlusal cavities in bicuspids and molars, it is inadvisable to attempt more than a combination filling. Some of the earlier dentists, whose experience antedated the discovery and successful use of cohesive gold, claimed to be able to make satisfactory contour operations in these cavities with non-cohesive gold alone. This was probably accomplished by much interlocking of the gold by driving the pieces one into the other with sharp points; but whatever may have been done in this direction in the past, is now a lost art, and the use of non-

cohesive gold up to the knuckle, and the building up of the rest of the filling with cohesive gold, is all that is now likely to be attempted. In these cases it is generally impracticable to depend in any way on the spreading power of the wedge, although, if a matrix is used, this procedure may be resorted to. The gold should be packed towards the cervical wall, leaving as much overlap as the presence of the adjacent tooth will admit of. The gold should be thoroughly condensed, and fine points should be used against the walls to ensure adaptation. When the knuckle is reached, cohesive gold is attached to the last layer of the non-cohesive gold before it is completely condensed, either by means of sharp, deeply-serrated pluggers, or by forcing small pieces of cohesive gold into depressions made in the non-cohesive, at the lateral walls. The cohesive top is then built up and securely locked in place by means of a step anchorage, or undercuts, in the occlusal surface. When all the non-cohesive gold is in place, the part still to be filled must be regarded as an independent cavity, with the non-cohesive gold forming the cervical wall. When the cohesive portion is completed, the non-cohesive overlap should be condensed as much as possible. Broad-faced hand-pluggers, with the condensing surface in the same plane as the shanks; foot-

pluggers used with a mallet, and thin flat burnishers, are all useful for accomplishing this.

Whenever non-cohesive gold can be successfully used it will be found, in many cases, to effect a saving of time, as far as the insertion and consolidation of the gold are concerned, and the work is accomplished with less eye-strain. As far as the excellence of the work is concerned, it must be admitted that, although in certain cases a perfect adaptation may be accomplished with greater ease and certainty, there is no possible adaptation with non-cohesive gold that cannot be equalled with cohesive gold; the latter has a wider range of employment, and a coherent solidity and hardness, that are essential in many cases.

Finishing Gold Fillings.—When the filling of a cavity is completed, the surface of the gold should be further consolidated and rubbed somewhat smooth with a burnisher, using firm pressure. The gold is then trimmed to the desired shape, the edges brought to fine lines, and the filling generally made fairly smooth with files, fine cut burs, stones, emery, or sandpaper strips and discs, &c., using one or more of the above as necessary. The burnisher should again be thoroughly used, and, if desired, the filling may be finally made as smooth as possible with a

suitable polishing powder applied in any convenient manner.

Some dentists are opposed to the use of a burnisher; they consider it unnecessary if the filling is of solidly condensed cohesive gold, and that it has a tendency to give the surface a wavy or slightly furrowed appearance, and imparts a lustre to the gold that is undesirable in exposed positions. A burnisher will, however, consolidate and harden the surface of solid metal. The writer was informed by a silversmith, that the burnishing of silver goods hardens the surface, and adds greatly to their durability. In order to obtain a fine finish they are also always polished afterwards. If a burnished gold filling is afterwards carefully polished, the æsthetic objection falls to the ground.

In using sandpaper or similar discs, it is advantageous to smear them over with moist soap. This prevents the discs heating, and adds greatly to the comfort of the patient. The disc also cuts more smoothly. A well-soaped coarse disc will finish up the filling quite as smoothly as a dry fine one. Soap is decidedly better than vaseline, glycerine, or oil. It has often been pointed out that the use of a lubricant on a disc causes the rubbed-off gold to adhere to it, and consequently it is an economical proceeding. Burs should also be prevented from

heating, by dipping them in a suitable lubricant. The amount of pain that may be given by the use of dry discs or burs can only be realised by one who has experienced it. It may also be mentioned, that a dentist who has had personal experience as a patient of the free and vigorous use of trimming and polishing strips below gum margins, will use the Rhein plug-trimmers, fine thin chisels, and thin flattened burnishers, as much as possible in this region, especially on bicuspids and molars, when cervical trimming with sandpaper discs is inadvisable. The finishing of gold fillings is often tedious, and takes up much time; there is usually very little space to work in, and freedom in the use of the methods employed is in many cases impossible. It may however be laid down as an axiom, that extra care and time spent in preparing a cavity will facilitate and improve the filling, and that extra care and time spent on the filling will reduce the time and labour necessary to spend on the finishing.

General Considerations of Gold as a Filling Material.—The value of gold as a tooth-saving material depends on an exact preparation of cavities on certain lines, an excellent manipulation of the gold in the cavity, and careful finishing of the filling. If the conditions are favourable for this, it is the best material. Its successful use depends not only on a

skilful operator, but on a good and appreciative patient. The dentist must be able to do the work, and the patient must let him do it. The preparation of cavities is comparatively a severe, and often a painful, procedure. Nervous, timid patients, and all whose teeth are excessively sensitive, are generally bad subjects for gold filling. The pain caused by thorough excavation is, in the majority of cases, easily bearable, particularly so if the patient understands the operation, and has a sufficient appreciation of the value of his or her natural teeth to realise the advantage of helping the dentist by exercising self-control. Many patients are intolerant of the slightest pain or inconvenience. Some imagine it is quite unnecessary, and consider it is the correct thing to make as much fuss as possible. There is hardly any dentist who can do this work satisfactorily when the patient is flinching and fidgetting, telling him every few seconds he is "touching the nerve," and asking continually how soon it will be finished, &c. Here and there may be found an operator of iron nerve and calm, unruffled disposition, whom nothing disconcerts, and who can do "good gold work" under all circumstances, but he will probably have the satisfaction (?) of frequently hearing, that, although he is considered a remarkably skilful operator, the severity

of his methods causes numbers of patients to forsake him for less thorough but more humane practitioners. The dentine is sometimes excessively sensitive, and even if patients can screw themselves up to bear the operation, its proper performance may cause an amount of suffering and shock that—particularly in the case of delicate patients—it is better to avoid.

Fortunately, these excessively sensitive teeth are not met with every day, and in contradistinction, there are some patients whose teeth can be freely cut into in all directions (avoiding the pulp) without causing them the slightest pain.

An experienced dentist readily ascertains the temperament of his patient, and it is distinctly advisable, and of the greatest benefit to the patient, to work accordingly. It is useless to so worry a patient to fill one tooth, that he or she acquires a dread of the dental chair, and can never be persuaded to submit to another operation, gradually allowing all the teeth to be lost through neglect. Whether a patient's teeth are really very sensitive, or whether he or she is simply intolerant of slight pain, or even inconvenience, has practically the same effect in deciding the wise dentist that gold fillings are inadvisable in these cases. In the former case it is much more humane to use other

materials, although they may not last so long, and in the latter there is every risk of the work being imperfectly done, and the result consequently unsatisfactory. Therefore the first consideration, if gold is to be used, is "a good patient." The next consideration is what may be called a fairly healthy mouth. Whenever there are evidences which point to the existence of a period of rampant decay, it is well to resort to more palliative work. It is a curious fact, but one that will have been often observed by dentists of experience, that under certain conditions, the more temporary materials, such as white cement and guttapercha, will save teeth far better than gold. Decay will readily attack the margins of the gold fillings, whereas the margins of white cement or guttapercha will frequently remain intact until these fillings are considerably worn away. A regular replacement of these temporary materials as soon as necessary, will often succeed in preserving teeth indefinitely, in mouths where, owing to frequent replacement of gold, and continual re-excavation, the teeth soon pass to the crowning stage. It is also as a rule inadvisable to use gold if a tooth has recently ached, and pulp-destruction is not resorted to, or if any diseased condition of the peridental membrane is suspected or has recently been treated. The

force used in inserting the gold may set up irritation in these cases, and it is always well to be cautious. It is very annoying to have spent considerable time on a gold filling, and then to be compelled to remove it, owing to a recurrence of some previously diseased condition.

Then again, the extent to which the tooth has been weakened by decay must be considered. Many teeth are decayed in such a manner that proper excavation for gold would cause them soon to break down, whereas many of these teeth may be successfully restored with a plastic material, such as amalgam, and the attachment of a crown to the root postponed for several years.

The main point to be considered—providing the patient is a good one—is the probability of the tooth lasting a long time if filled with gold. It is no use putting a filling which, under favourable circumstances, might last twenty years in a tooth that will probably only last two; and even when everything appears favourable, the dentist, if skilled and conscientious, will take every precaution to prevent further decay taking place, for beyond the fact that it will in itself resist the action of all the fluids of the mouth, no matter what their condition may be; and that if skilfully and carefully worked, it will not wear away or chip at the edges,

he knows there is nothing in the gold that will help the tooth to resist decay. He will, in many cases, enlarge the cavity, so that the edges where the joints between the gold and the tooth are made, can be kept clean and free from collection of food deposits, and which by their fermentation and consequent acid reaction might cause a recurrence of decay at these parts; and by being brought out just to where they can be readily seen and reached, admit of being quickly and easily repaired, should decay again take place. He will be careful to grind out all little roughnesses and defects from the edges of cavities, so that there will be no weakness or imperfection of the joint to invite an attack of the enemy. He will feel, in fact, that he is using a material that will last if the tooth will, and therefore he will take pains to enable the tooth to resist as long as possible. No one can prophesy how long a gold filling will last in any individual case, but if the conditions are favourable, the majority last sufficiently long to fully justify the time, care, and expense entailed in making them; and the dentist who inserts many gold fillings must necessarily be skilful and extremely painstaking—qualities which ensure his patients getting full justice done to them in all his operations.

Tin.—Tin as a filling material is now considered, because its use dates almost as far back as gold.

It is usually prepared in the form of foil, and used on the non-cohesive principle. Cohesive fillings have been made with tin, by using small shavings freshly cut from a block of tin at the time of the operation. It is also possible to make a cohesive filling with tinfoil, but this takes up far more time than working cohesive gold. For all practical purposes tin will be considered a non-cohesive material, and manipulated as such. It is softer than gold, and more easily manipulated and adapted to cavity walls. It is a low conductor of heat, and is therefore tolerated in closer proximity to a pulp than gold or any other metal used for filling teeth. Its value as a filling material *per se* is more than counterbalanced by its defects. It becomes discoloured and dark on the surface, and is not so resistant to the force of mastication as non-cohesive gold. The writer has found that tin fillings rot or disintegrate at the cervical margins of bicuspids and molars. This has frequently happened, no matter if the filling was entirely made of tin, whether it was used up to the knuckle and the operation completed with gold, or whether tin and gold were rolled up together in equal quantities, and used as recommended by the late Dr. Abbott and others. This rotting did not take place in every case, but occurred sufficiently often to compel the writer to

discard its use in an approximal cavity, unless it was completely covered up with gold.

Many dentists who have used tin, deny that it rots, and the only means of reconciling these opposed statements, is to suppose that the tinfoil supplied to dentists is not always pure. It is well known that much of the ordinary tinfoil of commerce is lead coated with tin.

A reference to Taft's "Operative Dentistry," (p. 83, 4th edition) will show that the writer's experience with tin is not unique. Tin is useful for flooring deep occlusal cavities that are to be filled with gold, and a base for cohesive gold can often be made more easily and quickly with tin, than with non-cohesive gold in occlusal cavities. It would also be extremely useful for starting gold fillings in posterior cavities in bicuspids and molars, if its maintenance of integrity could be relied on. When used in contact with gold its exposed surface becomes perfectly black, and it is therefore out of place whenever this part of the filling is exposed to view. Its use in incisors and cuspids is also generally contra-indicated, for even if completely covered up with gold, it gives a dark, leaden appearance to a labial wall. Whenever a cavity is floored with tin, or whenever it is used for starting a filling, it is a great convenience to be able to attach the gold to

it on the cohesive principle. The sponge or crystal gold, known as Solila gold, coheres fairly readily with tin. Leslie's crystalline gold also coheres with tin, but this gold seems to have dropped out of the market. Dr. Shumway produces cohesion between gold-foil and tin by means of a hot plugger.

A mere filament of tin added to non-cohesive gold was used by the late Dr. Lord. This does not interfere with the colour of the gold filling, it renders the manipulation easier, and in time the filling becomes considerably harder. Not more than a strip one-sixteenth of an inch wide should be folded up with a whole sheet of No. 4 foil, or else the surface of the filling will show black patches. It is wonderful how a very small quantity of tin seems to work through and into the whole filling. The strip of tin may be placed on the edge of the sheet of gold, and the gold then folded over the tin in such a manner that the tin is in the centre of the folds. If the folding is loosely done, the gold may be finally twisted into a rope, from which pellets can be cut.

Amalgam.—An amalgam for filling teeth is produced by mixing one or more metals with mercury. The only single metals that have been used for this purpose are silver, copper, and

palladium. For some reason palladium is now rarely if ever used, and will not be further alluded to.

The amalgams that are now generally used, are made by melting together several metals, and pouring them into an ingot mould. The ingot is then reduced to fine filings, or shavings, and mixed with the mercury. Of the various metals that have been used for making these alloys, tin, silver, gold, copper, and zinc, are the ones that are most employed. Platinum is used in some alloys, but is thought of little or no value in this connection. One of the main points that careful investigation has brought out is, that silver is the metal that must be used in the largest proportion in making an alloy, and that at least 60 per cent. of silver is necessary. Tin is necessary in order to enable an alloy to be satisfactorily mixed with mercury, and it has been termed a flux for this reason. Its proportion comes next to silver. A good amalgam alloy can be made with tin and silver alone, and in this case the proportion of silver should be from 65 to 74 per cent., depending on whether the alloy is used fresh cut or annealed. Dr. Black finds that the best formula for a silver-tin alloy pure and simple (fully annealed) will be close to 73 silver and 27 tin.

Silver gives strength, expands, and discolours; tin contracts. Gold has been used to decrease contraction, and improve strength and colour; copper to decrease shrinkage, or control the expansion of other metals, and add to their tooth-saving properties. Zinc expands and improves colour. All these different metals possess different properties when melted up together, reduced to filings, and mixed with mercury. The desire has always been to use them in such proportion that what may be called a perfectly balanced alloy that will give a perfectly balanced amalgam will result. The one great and final test is the behaviour of the amalgam when placed in teeth in the mouth. After many years' experiment Dr. Flagg has finally come to the conclusion that gold is valueless as a constituent of an amalgam alloy. He also says that copper, as copper, and zinc, as zinc, are diametrically opposed to one another, and for this reason he has never made such a combination. For many years the Contour amalgam alloy made by Dr. Flagg consisted of silver, tin, and gold. His Submarine alloy was composed of silver, tin, and copper. In the *Dental Cosmos*, February 1900, he states that a very gradual increase of copper now gives the formula of Submarine as silver 60, tin 33, copper 7; and the formula of the Contour alloy is there given as from

60 to 70 silver, from 25 to 35 tin, from 1 to 3 gold, and from 1 to 3 zinc. In "Plastics and Plastic Fillings," (6th edition, revised 1901) Dr. Flagg states that gold is valueless as a component of a dental amalgam alloy, and that this conclusion was not arrived at before July 1900. The presumption therefore is, that Dr. Flagg's Contour amalgam alloy now consists of silver, tin, and zinc. The Fellowship alloy, as well as two or more others, that have sprung into existence since the publication of Dr. Black's experiments, consist of silver, tin, copper, and zinc. An analysis of Fellowship alloy gives silver 67·73, tin 26·33, copper 4·71, zinc 1·23; and some other alloys are almost identical.

The alloy to which the name True Dentalloy has been given by the makers, is said to consist of silver 72·5, and tin 27·5. The analysis of an alloy will not give the exact proportions of the metals that are put into the crucible, owing to some slight loss that occurs during the melting. It is also stated that a good formula will not necessarily give a good alloy, owing to loss of metals that may occur during melting, and uneven distribution of the metals in the ingot.

Dr. Flagg considers that his Submarine alloy makes—owing to the copper it contains—an emi-

nently tooth-saving amalgam; the Contour alloy, being a general purposes alloy, possessing great edge strength, and better colour. Some dentists claim that by mixing together the filings of two or more amalgam alloys, they obtain a better amalgam filling than in any other way. They claim that a melting together of the mixed filings, or the making of an ingot which contains the various metals in the same proportions as the mixed filings, does not give the same results. There is no doubt that amalgam fillings in general have proved disappointing, and how much of this is due to improper proportions of the alloy, and the improper mixing of the amalgam, time alone will show. That many alloys have been extensively advertised and used, which experiments have shown could by no possibility have given good results, is proven; and there is every probability that, thanks to the investigations of Dr. Flagg, Dr. Black, and others, the amalgams of the present and the future, will serve a better purpose in saving teeth. The principal defect in amalgam fillings is their great tendency to curl away from the cavity margins. This leads to either the amalgam edge, or the edge of the cavity, or both, becoming chipped or broken by the force of mastication, with a recurrence of decay as a natural consequence.

In many cases, even if no break occurs, the curling up of the amalgam edges produces a trench or cavity for the collection of food particles, with equally disastrous results. This curling up of the edges takes time, and although there is a great deal of difference in the behaviour of different alloys in this respect, three years is generally sufficient to produce these defects. It has been noticed that this curling up of the edges is particularly manifest on occlusal surfaces, and more particularly on the occlusal surfaces of approximo-occlusal cavities. There is no doubt that many amalgam fillings seem to "grow out" of the cavity on buccal surfaces where they are subjected to no force of mastication, but that the force of mastication on an amalgam filling increases this even if, in many cases, it does not produce it, will be apparent to any one who has used his powers of observation for a number of years.

Dr. Black explains this as being due to the flow of the metal (amalgam) under force or pressure. It has also been pointed out by Dr. Black that an amalgam filling made of filings, or shavings, varies considerably both in its mixing or working properties, and in its behaviour under tests for shrinkage and flow. The explanation is, that filing or cutting up an ingot hardens or tempers the particles into which

it is reduced, and that in eourse of time, owing prineipally to inerease of atmospheric temperature produeed by the heat of summer, or the artifieial heating of rooms during eold weather, these filings or shavings beeome gradually untempered or annealed. In order to prevent this variation in the behaviour of amalgam fillings, Dr. Blaek set himself to work to produee alloys that would give good results in the untempered state, by annealing the filings or shavings. This is usually accomplished by enelosing them in a bottle or flask, and placing the flask in boiling water for a certain time. From fifteen to eighteen minutes is sufficient to thoroughly anneal an amalgam, although doubtless the time will vary with different alloys, and must be determined by experiment. It is stated that it takes two years for an amalgam alloy to become completely annealed by time ageing. It is also stated that the older the alloy is after a eertain age, or the longer it is annealed after a eertain annealing, the weaker it will be (Dr. Black).

Many amalgam alloys, when used freshly eut and without annealing, are much more difficult to mix with mereury, and the production of a suffieiently plastie mass to admit of eomfortable and satisfaetory manipulation, is not only more difficult, but demands a large proportion of mereury. The same

alloys, when used some considerable time after they have been reduced to filings, will generally mix into a smooth plastic mass quite readily, and with less mercury. This ageing of alloy filings is considered by Dr. Flagg to be a distinct advantage in all cases; while Dr. Black, on the contrary, considers that with certain formulæ it is a detriment. The advantage of using an untempered alloy consists not only in its superior mixing and working properties, but in the fact that, when once it is untempered, it is likely to behave always in the same way. The advantage of using alloys that give good results in the untempered state is therefore manifest. When experts differ it is hard for an ordinary man to know which line to follow. The difference between Dr. Flagg's conclusion, and that arrived at by Dr. Black in this respect, seems to be, that while the former holds that all alloy filings are improved with age, and slow untempering, the latter considers that the composition or proportions of the alloy should vary according to whether the filings are used in a tempered or untempered state.

Apart from the superior mixing qualities of the majority of untempered alloys, the trouble necessitated in keeping the alloy in the ingot form, and filing off sufficient for the case in hand each time, in order to secure even results, is sure to prevent its

general adoption. The use of aged or annealed alloys is therefore of importance. Whether a freshly cut, but fully annealed, alloy will afterwards become unduly annealed by an after-time ageing within a reasonable period, should be known; and in view of a probable deterioration through age, it would be well for the makers to place the date of the annealing on the label, and state for how long a time the alloy will remain in perfect condition. There is still a great deal to be learnt about dental amalgams, for the subject has by no means reached finality. That much progress has been made which will lead to the use of better alloys, and better methods of using them, is something that the dental profession should be thankful for.

The method of mixing an amalgam is of importance, and a good deal of misapprehension exists on this point. The accurate, or fairly accurate, weighing of the alloy, and the mercury before making the mix, does not so much depend on the necessity for securing exact proportions of alloy and mercury in the filling, as on the manner in which the mix can be made. Dr. Flagg states that the mix should be accomplished in definite proportions, with one *admixture*—that is to say, that the weighing of the ingredients enables a mix of the desired consistence or

plasticity to be obtained without an alternate adding of mercury and filings. It is this usually adopted practice, of alternately adding first one, and then the other of the ingredients, until a mass of the desired plasticity is obtained, that Dr. Flagg deprecates. He claims that this will ruin the best amalgams, and that under proper tests, there is no comparison between the results obtained by these two methods of mixing. It is also found that an amalgam made with one admixture, produces a better plastic mass with less mercury; and the excess of mercury that is often necessary, in order to secure working properties in an amalgam prepared by the haphazard alternate mixing method, will transform an excellent amalgam into a comparatively poor one. (See "Plastics and Plastic Filling," chap. ix.) The proper method of mixing an amalgam filling, is to weigh the mercury and alloy in such proportions, as have been found upon trial, to make the mass just right for working in any given case. The balance designed by Dr. Wheeler, and made by the S. S. White Company, is a very correct one for this purpose.

Dr. Flagg says:—After determining the proportions of mercury and filings, they are placed in a mortar, and the filings "*gradually* incorporated with the mercury." "This is done by retaining the mercury in the centre of the bottom of the

mortar, and by a circular motion, *occasionally reversed*, drawing in the filings little by little." "The mass is then gathered by the finger from the mortar into the palm of the hand, and is kneaded until it becomes a button." The button is then spread out by careful and thorough rubbing in the palm with the finger, again gathered up into a button, and this process is repeated until a perfectly homogeneous plasticity is attained. "It is during this manipulation, oftentimes repeated, that the 'crepitation' of an amalgam is heard."

Dr. Black says that the proper amount of mercury should be mixed with the alloy to begin with, not so much because squeezing out will injure it, but because the mix cannot be properly kneaded if there is too much mercury in it. He also says that the alloy he has found to give the best results works into an amalgam very slowly, and it requires a great deal of kneading to obtain the proper condition of the mass. "To get a smooth-working property, they should be kneaded a considerable time, and you cannot do this kneading properly if there is too much mercury in the mass. They need to be kneaded until the granular appearance has fairly disappeared, and they will work into a plastic state."

Different alloys will require different proportions

of mercury in order to obtain the best results. The proportion of mercury has little effect on shrinkage or expansion, but either too much or too little mercury will produce a weak amalgam that crushes at far less stress than one that has been properly mixed (Dr. Black).

The method of packing amalgams into a cavity is of importance. Because it is a plastic material, it is generally supposed that its perfect adaptation to cavity walls is a simple proceeding. A few experiments made out of the mouth will show that this is not so easy as it seems, and the general method of rubbing it against the walls with ball-ended burnishers is productive of uncertain results. Dr. Flagg says that after each piece is placed in position, it should be crushed by a round-end or flat-end plugger, and then tapped with light blows from an appropriate instrument, until it is placed in accurate apposition to the walls of the cavity. The use of a mallet is "not only unnecessary, but really objectionable. It is not needful that the blows should be in any degree *forcible*, but, on the contrary, it is better that they should be such as would more properly come under the signification of 'taps.' The consistency of the amalgam should be such as will permit of perfect adaptation of filling to cavity wall, by tapping with light blows." "This

'tapping' is *not to be done* with mallets, either hand, automatic, or electric, as a different kind of blow from any so given is far preferable. The 'tap' from the filling instrument—the same used for crushing—is a mingled push and blow, which is soon acquired, and is as promptly recognised as very efficient in producing admirable results."

Dr. Black advises the use of a few large pieces of amalgam, in preference to a larger number of smaller ones, and considers that as broad-faced a plugger as can be conveniently used should be selected. The plugger should have a flat, finely serrated face, and the force used in packing amalgam should be as great (if not greater) as the force used in condensing gold with hand pressure. The late Dr. Bonwill packed amalgam with great force, placing a pellet of Japanese bibulous paper on the amalgam, and forcing some of the mercury up to the surface, and out of the cavity.

No matter what method of packing is resorted to, it will be found that a properly mixed amalgam that is inserted with the promptness that its setting qualities may demand, will—particularly in large cavities—become somewhat sloppy on the surface. This is counteracted, and prompt trimming and smoothing readily effected, by "wafering" the

filling. This is done by placing part of the amalgam in a piece of chamois leather, or linen cloth, twisting the leather or cloth tightly around the amalgam, and then squeezing the amalgam with large strong pliers. The leather, or cloth, should be held tightly around the button of amalgam, so as to prevent any of the mercury being squeezed into the folds of the leather, and becoming re-absorbed by the wafer. All the mercury that it is possible to "get out" of the amalgam thus finds its way through the pores of the leather or cloth. The wafer is then broken up into suitable sized pieces. If this squeezed amalgam is applied to the surface of a completed filling, and thoroughly incorporated by careful and proper packing, it materially assists in the setting of the filling. In large cavities it is often necessary to apply the wafers before the filling is completed, thus filling up part of the cavity with well-squeezed amalgam. When wafers are added to a completed filling, it is often a convenience to scrape off the plus surface thus produced, and re-apply more wafers, until the filling is sufficiently hard to be trimmed and smoothed.

It is important for an amalgam filling to be completely trimmed and made smooth before the patient leaves the chair. It is very tedious and difficult to

trim and smooth a rough amalgam filling when it is completely set, especially on the approximal sides of bicuspids and molars; and in these positions it is usually a painful process for the patient, owing to the free use of trimming and polishing tapes below the gum, necessitated by maintenance of contour. All that should be done when the filling is set, is to perfect the surface with the finest polishing strips, pumice-stone applied with wet linen or silk tapes, followed, if thought necessary, by tapes charged with chalk or whiting. The occlusal and other equally exposed surfaces can, of course, be easily ground smooth with stones in the engine, and polished with wooden points or leather buffs, and a suitable powder; although the necessity for any grinding is done away with by careful scraping and smoothing at the time the filling is made.

Dr. Flagg has pointed out that whenever amalgam is squeezed in chamois leather, the mercury appears to come away clean; while, if the unenveloped amalgam is squeezed in the fingers, the consistence of the expelled mercury shows that it is carrying away with it some of the alloy in solution. This, however, varies very much, according to the amalgam used. With some amalgams squeezed in the fingers, there seems to be little if any thickening of the mercury, while with others, the squeezed out

mercury is evidently loaded with the alloy. Whether the squeezing out of much or little of the alloy makes any difference to the value of the filling; and whether the absence or presence of a good deal of alloy in the squeezed out mercury is advantageous, detrimental, or immaterial, probably depends on the composition of the alloy, but the subject has not yet been investigated. It seems, however, to be rather absurd to use an alloy in the production of which great care has been taken to secure exact proportions, and then to destroy these proportions by squeezing an indefinite quantity of each ingredient out with the mercury. The alloy should therefore be mixed with the mercury in such definite proportions as will secure the best mix; and then, if wafering is necessary or advisable, to squeeze out the mercury in such a manner that it carries out with it little or none of the alloy. The maintenance of colour in an amalgam filling is very uncertain, and just in proportion to maintenance of colour, so are the tooth-saving properties of the filling reduced. This is to say, that although an amalgam that maintains its colour may save certain teeth remarkably well, there are other teeth in which a filling that readily oxidises and becomes more or less black, is more advantageous. It is difficult to account for this, but that certain

amalgams have a hardening effect on the dentine with which they are placed in contact, and also that—all other things being equal—an amalgam that goes black on its exposed surface seems to preserve bad cases better than a non-oxidisable metal filling does, is a common belief based on observation. Dr. Flagg recommends the use of two amalgams in many cases, viz. one that oxidises, or "sulphides," for guarding the cervical parts, and one that maintains its colour better for the rest of the filling. It may therefore be said that, just in proportion as the conditions of the mouth, &c., favour decay, so is the use of an eminently tooth-saving amalgam demanded; and just in proportion as the surrounding conditions are favourable, so may a lighter coloured amalgam be used with advantage. It is found, however, that any good, light-coloured amalgam will maintain its appearance best on surfaces that are exposed to friction, and that it is a rare experience for any "front tooth alloy" to in any way maintain its colour in incisors. To the writer's eye an exposed amalgam filling in an incisor or canine is by no means a thing of beauty, even if by some chance it should perfectly retain its original colour.

Some years ago he made several fillings in front teeth with the No. 3 platinum-gold-foil, which

finishes up platinum colour; and as in every case he found that the teeth would have looked much better if filled with gold, he came to the conclusion that a silver-white filling was far more hideous than a gold filling, and that, for æsthetic reasons alone, amalgam, even if it should maintain its colour, has no place in front tooth cavities that are in any way exposed to view.

The two metals that oxidise the most readily and thoroughly in the mouth are silver and copper, and these are the two metals that, used in combination with mercury, exert a preservative effect on tooth structure. The preservative effect of an amalgam of copper and mercury alone is far more than counterbalanced by its defects, and an amalgam of coin silver alone, which is really a silver amalgam containing about ten per cent. of copper, has many defects which preclude its general use. Dr. Flagg says: "It turns black, and discolours any kind of tooth dreadfully. It curls up at the margins in an undesirable manner. Its edge strength is not good, but notwithstanding this it saves teeth in a remarkable manner, even in the most desperate cases." Dr. Flagg also says: "In many a cavity where everything else, even copper amalgam, has failed, it has done faithful duty *persistently*."

The method of making coin amalgam described

by Dr. Flagg is to reduce a silver coin to fine filings with a "dead smooth" file. The filings are then sifted through a very fine sieve, and a magnet freely and frequently applied to remove all particles of steel that may have come off the file. Dust is removed by careful blowing, and about 55 parts of mercury to 45 of the filings is required to make the amalgam mix; rub into paste in mortar. If amalgamation is not prompt and complete, add a globule of mercury to make a smooth paste; squeeze through chamois; again triturate thoroughly in mortar; squeeze as for wafering; introduce filling as usual; take off soft surplus, and wafer.

Copper Amalgam is made by dissolving pulverised sulphate of copper in warm water, and precipitating the copper by means of either iron or zinc rods or plates. The details of procedure are to be found in several books, and need not be here mentioned. Suffice it to say that the precipitated copper is mixed with mercury, and formed into buttons or discs of convenient size. One or more of these buttons is heated (when perfectly set) in a suitable spoon, over a spirit lamp, until globules of mercury appear. The button is then placed in a mortar, crushed up, and thoroughly rubbed with the pestle. The amalgam is then transferred to the hand, and

again carefully rubbed with the fingers until it becomes very plastic. The superfluous mercury is then squeezed well out, and it is ready for insertion. It is considered that the iron precipitate produces more even and trustworthy results than the zinc precipitate.

Copper amalgam gives no flow under pressure, and consequently never curls up at the edges. It is also considered to shrink very slightly, or not at all. It can be placed in a tooth in a very plastic condition, and will set very hard. If a *little* soft dentine is left in the cavity it will be permeated by the copper salts, stained a dark colour, and any decay that might otherwise have progressed underneath the filling will be prevented. It will be seen therefore that it possesses certain valuable properties. Its colour, although black, is not of much moment in cavities that are not exposed to view. It will not discolour a live tooth if all the soft dentine has been removed, and the walls are formed of hard, white dentine, but will turn a pulpless tooth very dark. Its merits are, however, more than counterbalanced by its defects. It wastes away on the surface, and in some cases rots, or becomes dissolved away, at the cervical margin. In fact, except that it is somewhat more durable, it behaves in these respects very like a cement filling. The general

waste or wear soon causes the contour of approximal fillings to be lost, food to become wedged between the teeth, and extension of decay to take place in consequence, while the cervical wasting when it occurs increases the mischief.

Owing to its hardness, it is extremely difficult to cut out, and this is often necessitated for the above reasons. It can, however, be often used with advantage in occlusal cavities and fissures in bicuspids and molars—particularly for young and fidgety patients—and for cavities on the sides of molars, and sometimes bicuspids, where, owing to the extraction of the adjacent tooth, the filling is perfectly free and can be easily repaired when necessary. A cavity can be very rapidly filled with copper amalgam, and as the surface soon becomes smooth from wasting and wear, there is no necessity to spend much time in finishing the filling. If its use is confined to the above-mentioned cavities, including buccal and palatal surfaces of molars, and occasionally bicuspids, as well as to all cavities in temporary molars that admit of an amalgam filling, and only need to be preserved for a few years, it will be found to give great satisfaction in many cases, particularly if the teeth are sensitive and the retainage doubtful, and the mouth is too wet to admit of the use of white cement or an alloy

amalgam with a cement lining, and it is desired to dispense with the rubber dam.

Combination (Mixture) of Copper and Alloy Amalgam.—It might naturally be thought that a mixture of copper amalgam and an alloy amalgam would increase the merits and reduce the defects of either used singly. It might be supposed that the admixture of copper would reduce the flow and shrinkage of an alloy amalgam, and that the alloy would reduce the wasting away or rotting of the copper. The writer has made a large number of such fillings during the last eight years, and finds that his expectations have been fulfilled. It has been stated that this mixture is of no value, inasmuch as the filling acts just like either a copper or an alloy amalgam, depending on the proportions of the mix. Either the filling shows all the wasting and rotting of a copper amalgam, or else it shows all the curling up of margins associated with an alloy.

The writer's experience is that whenever the filling wastes away, this process is very slow compared to copper amalgam; moreover, good edges are maintained, and when no waste takes place, any curling up of edges is very slight, and apparently of little moment. The writer's method is to soften and rub the copper amalgam in the usual way, then to mix the alloy with mercury to

the same consistency as the copper amalgam. Equal parts of each amalgam are then rubbed together, first in a mortar, and afterwards in the hand, the surplus mercury being squeezed out in the usual way. It is impossible to obtain perfectly even results, owing to the different amount of mercury that various batches of the same make of copper amalgam contain, and also because the mixing of the alloy to the same consistency as the copper amalgam can be only approximately determined; further, the best alloy for forming the mixture has not yet been ascertained. It may be mentioned, however, that some alloy amalgams mix much more kindly with the copper amalgam than others, and there is also a wide difference in the setting properties, according to the alloy that is used. The writer is convinced there are great possibilities in this mixture, and that a full investigation would prove most useful. The conclusion the writer arrives at is that it is an eminently tooth-saving amalgam, and for this reason it is a more durable material or filling than the majority of alloy amalgams. It turns perfectly black on the surface.

The Matrix.—There is a difference of opinion as to the value of a matrix in filling certain cavities. Many operators make frequent use of this appliance in mesial and distal cavities in bicuspids and molars,

and some find it is also of great assistance to them in filling the incisors and cuspids. It is in filling cavities with amalgam that the largest use is made of a matrix, and it is therefore appropriate to briefly allude to it now.

As far as gold is concerned, the matrix may or may not prove useful. This will depend on what may be termed the individuality, or methods of manipulation, of the operator. The cases are comparatively rare in which a matrix will facilitate or improve a gold filling, and although some operators make large use of it, finding it decidedly advantageous; others work quite as easily, rapidly, and accurately, without it, and would indeed regard it as greatly interfering with their work. In filling approximo-occlusal cavities with amalgam, however, it is considered to be of great value by a large number of dentists. In the opinion of the writer, its principal value is in connection with quick-setting amalgams that demand great pressure in order to bring about the best results. There is no *necessity* to use it if an amalgam of average plasticity and average setting qualities is employed. In making an amalgam filling in an approximo-occlusal cavity, the following method will give good results without a matrix, presuming the amalgam is a suitable one as

regards plasticity and setting qualities:—Fill the cavity, and build up against the approximal surface of the adjacent tooth. Roughly trim the sides and occlusal surface, and wafer until sufficiently hard. Trim the occlusal surface to the bite, and make it fairly smooth. Trim the sides and cervical margin, and shape or smooth the filling nearly up to the knuckle by passing thin, spatula-like trimmers into the interproximal space. Clear away any loose bits of amalgam from the interproximal space with a stream of water from a syringe. Pass a fine ribbon saw between the teeth from the occlusal surface. Then pass a strip of thin silk ribbon between the teeth, and draw it backwards and forwards, making pressure on the filling until the amalgam is brought to a smooth and properly shaped contour. If necessary, perfect the cervical margin with a thin spatula. When the filling is completely set, it may be polished if thought good. The space made by the ribbon saw is not increased by the silk ribbon, and is no greater than if a matrix had been used. In a very short time this space closes up, and the teeth are in contact at the knuckle.

Eichentopf's Separating and Finishing instruments (Fig. 10) are very convenient spatulas for trimming

the approximal surfaces of amalgam fillings. They are very thin and pliable, and can be easily bent to any desired angle.

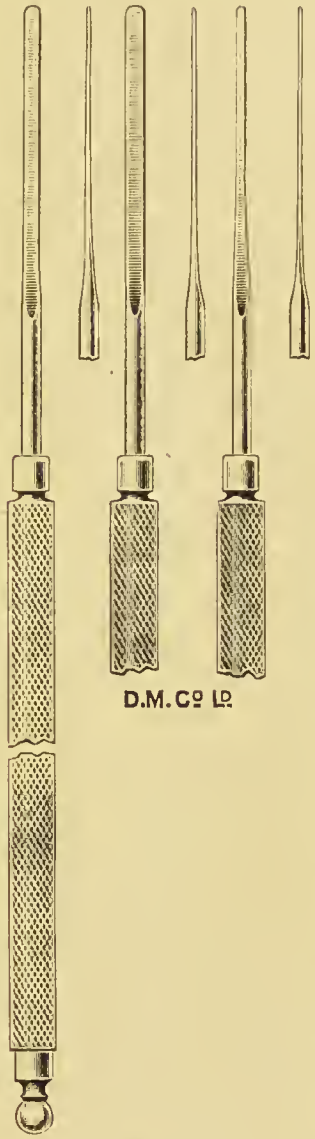

Fig. 10.

General Consideration of Amalgam Fillings.—The disadvantages of amalgam have been pointed out, and some of its advantages alluded to. One great advantage is the comparative ease and rapidity with which it can be introduced, and the hardness and general insolubility of the material. Its colour is not good, and any of the lighter coloured kinds that are useful for general purposes will deepen or become tarnished according to the position of the filling. A large approximo-occlusal filling, for instance, may maintain its colour on the masticating surface as far as the knuckle; from the knuckle it will often show gradation of colour varying from a slate-like or dirty grey from the knuckle, to an almost complete black at the

cervical margin or gum-line. Owing to its inherent defects of shrinkage and curled up margins it is not as good a material as gold, where the conditions are favourable for gold, but just in proportion to the presence of unfavourable conditions, so its superiority over the more precious metal is manifest.

Strictly speaking, a cavity that is properly prepared for gold is the best cavity for amalgam, but what is essential for gold is by no means essential for amalgam. The very plasticity of the material enables amalgam to be readily pressed into any deep depression or undercut that may exist after a mere removal of the decay is effected; and any cavity that is larger in its interior than at its orifice, can be well filled with amalgam without the extensive mathematical cutting that is needed with gold. It must, therefore, be allowed that amalgam is superior to gold for filling many teeth at the back of the mouth—or in cases where the filling is not exposed to view—for all patients who are sensitive or nervous, or who cannot endure prolonged operations. The question of hard and soft teeth need hardly be considered, for what is known as a soft tooth is generally one that is softened by decay, and the cutting back to sound, hard tooth structure, and the consequent production of a hard tooth becomes usually merely a question of cavity preparation, and it is on the

question of the possibility or the advisability of properly preparing a cavity for gold that the use of the precious metal mainly depends.

White Cement.—The white cement fillings are usually oxychoride of zinc (a powder of specially prepared oxide of zinc, and a liquid of chloride of zinc), or what are variously termed oxyphosphate of zinc or phosphate of zinc. These oxyphosphate or phosphate fillings also consist of a powder (some form of specially prepared oxide of zinc), and a liquid, principally, if not entirely, composed of phosphoric acid. The general term osteo, or osteo filling, has also been given to these various white cements, probably because one of the earlier productions was labelled "Os artificiel," or artificial bone. The oxychloride is now comparatively rarely used. It is more troublesome to work than many of the oxyphosphates, and must not only be kept perfectly dry during insertion, but also carefully protected from moisture for some considerable time afterwards by careful varnishing. It appears to be harder than the average oxyphosphate, but is, as a rule, not so durable in the mouth. It often causes pain on insertion, and is said to have a hardening and preservative effect on soft dentine; but this is very doubtful. It is considered to make an excellent root filling—one that will remain moisture-tight

and non-absorbent—while the oxyphosphates are considered to make leaky or absorbent root fillings.

As far as filling cavities is concerned, there is no question as to the superiority of the oxyphosphates, notwithstanding the more or less temporary or ephemeral character of any white cement hitherto produced. In mixing these fillings a little of the liquid and a little of the powder are placed on a glass or porcelain slab, and the powder is gradually worked into the liquid, and then more powder is added by firm rubbing with a stiff spatula until a putty-like mass is produced. The mass should then be rapidly inserted and pressed to place in the cavity, and the surface trimmed to shape as it sets.

Whatever may be said as to the value of mixing the liquid and powder in such proportions that an exact chemical compound results, it must be admitted that this can rarely be accomplished; and experience shows that the most durable fillings are those in which the liquid has been made to take up as much of the powder as possible. Too much powder will, however, produce a crumbly mass, and the manipulation should produce a putty-like mix that is, on the one hand, sufficiently stiff, and on the other, sufficiently plastic, to admit of being readily

and accurately inserted and packed to place. The mass may be pressed into the cavity with a broad, flat, spatula-like instrument, and then well pressed to the walls with blunt pluggers. The filling should be made "all in one piece," and not added to like an amalgam filling.

Different makes of this cement require different methods of mixing, and the rapidity of the setting varies considerably. A method of mixing that will give good results with one make will render another unworkable; some can be readily brought to the putty-like state, by the gradual addition of powder to the liquid on the slab. With other makes the addition of powder must cease before the putty-like stage is even approached, and this thinner mix must be continually spatulated until it gradually stiffens up to the desired consistency. There is very little difference in the durability of any good make of oxyphosphate cement, and an operator should, as a rule, select one that *he* finds easy to mix and work with. The writer finds, from an observation of the oxyphosphate fillings he has inserted during the last eighteen years, that the cervical failure, so often alluded to, is, in his experience, the exception rather than the rule. In many cases, cervical failure may be due to the use of a cement in either a too stiff, or a too sticky, condition. In the

former case, the filling either never goes fully up to the cervical margin, or else it arrives there in a crumbly condition. In the latter case, it probably sticks sufficiently to the plugger to be drawn away from the wall. It has, however, been stated that cervical failure is the rule with some makes of cement, and the exception with others. This probably accounts for the differences of opinion that exist on this point. Oxyphosphate fillings possess the inestimable advantage of adhering somewhat to the dentine (providing it is dry), and consequently in sensitive teeth there is often no necessity to cut retainage in the sound tooth structure. The decay, if possible, should always be removed; and it should not be forgotten that there are extremely shallow and extremely saucer-like cavities in which even cement will not stay. The modern use of porcelain inlays reduces the number of cavities it was formerly necessary to fill with cement alone, and at the present time cement as a filling material is principally of value as a preparatory filling, or preliminary treatment of certain cavities before using—or in the hope of subsequently using—a more permanent material. It has an average duration of from one to two years, and can be often successfully used to "tide over" a bad time as regards either a period of

rampant decay, bad health, or what may be called the foolishness and restlessness of youth. It is surprising how these oxyphosphate cements will save teeth when almost everything else, except gutta-percha, fails—and gutta-percha will not stand long if subjected to the force of mastication. A competent authority has placed small value on cement fillings as savers of the teeth just when the circumstances for saving them are unpropitious; but the experience of the writer is that if the decay can be removed from the walls, the margins moderately well prepared, the cavity sterilised, and the filling kept from moisture until it is properly packed and trimmed, a recurrence of decay will rarely take place at the margins until the filling is considerably worn or dissolved away. The principal use for cement fillings will always be in front teeth, chiefly because the majority of patients will not come up for regular inspection, and recurrences of decay that are solely due to neglect in this respect compel the use of amalgam (with or without a lining of cement, as may be thought good) in many cavities in back teeth, which an operator who was assured of complete control of his patient would have preferred to first fill with cement.

Whenever there is a possibility of a cement filling

becoming wet, either during or immediately after insertion, the rubber dam should be used. An oxyphosphate filling will become perfectly hard in water, but it is generally considered advantageous to varnish the surface. The majority of these cements are "hydraulic"; this is to say, that as soon as they have become reasonably hard, the absorption of a little moisture tends to improve them. This is probably why those operators who smooth their cement fillings with an instrument dipped in vaseline or oil, and well rub the lubricant over the surface of the filling, find they obtain as good results as if they used varnish. There is no doubt that the majority of oxyphosphate fillings become harder in time: a filling, the surface of which is tested twenty-four hours after insertion, will be found not quite so hard as it would be in a week, and probably not so hard in a week as it would be in a month, and this increase of hardness is taking place in the presence of moisture. There is one practical point that must not be overlooked, namely, that an oxyphosphate filling must usually be cut out and replaced within two years. Some cements are much harder to cut out than others, and the durability of a cement filling by no means depends on its hardness. There are many good cements that may be comparatively easily and rapidly removed, and are

therefore to be preferred to those which attain a rock-like hardness.

The writer tested the cements he is in the habit of using as follows: a ball of putty-like consistency was made, immediately dropped into Stephen's ink, and left there for twenty-four hours; a slight permeation of the cement resulted. Experiment No. 2 —A similar ball was made, and a pin was inserted into it to hold it while it was varnished; the varnish was partially dried with a chip blower, the pellet was dropped into the ink, and left there for twenty-four hours; in this instance no permeation of the cement resulted. Similar experiments made with the liquid of this cement, and the powder of another cement, produced precisely similar results. Another popular cement was then tried, with the result that it was completely permeated, whether varnished or not, and the unvarnished cement when removed from the ink was found to be considerably reduced in size. These little experiments are mentioned merely to show that a wholesale condemnation of cements because some of them are readily permeated is hardly fair. The writer does not for a moment consider that the cements he tested with such good results as regards permeability are very much better than many other makes. They are good cements with

an average durability of eighteen months before needing to be replaced in the mouth—that is all. It is considered that a steel spatula should not be used for making the mix; it should be heavily nickel-plated, or, better still, made entirely of nickel.

Gutta-Percha.—The gutta-percha specially prepared for filling teeth is a very valuable material but requires judgment in using. The softer kinds are of great general utility as coverings for dressings, and the harder or more permanent preparations, if used in cavities that are not exposed to the force and friction of mastication, probably give better results, taking one case with another, than any other material; a good deal, however, depends on the quality of the material. Gutta-percha deteriorates with age, and dentists would therefore be benefited if manufacturers would put the date of preparation on each packet.

Small cavities in incisors and canines are readily filled witht his material, and such fillings will usually last for some years; but a medium or large-sized approximal cavity is better filled with oxyphosphate, when gold or a porcelain inlay is contra-indicated; but when the cavity does not extend either to the lingual or labial surface, gutta-percha will last longer than a white cement, and

is easier to replace. Small pin-head holes on the approximal surfaces of bicuspids and molars are particularly suitable cases for gutta-percha—filled with gold, decay will usually attack the margins within a year or two. The writer would always expect a gutta-percha filling to last longer than a gold one in these cases, and, if necessary to replace it, it can be done in a shorter time.

Some authorities explain the rapid failure of these small approximal gold fillings to want of extension for prevention; others put it down to imperfect manipulation. But the most ardent contourist and believer in the necessity for freely exposed margins would not think it right to cut away all the side of a tooth, and hollow out its interior, in order to convert a minute cavity into a magnificent contour filling. And even if the failure of minute gold fillings in these positions is attributable to imperfect manipulation, it must be admitted that not one dentist in a thousand can do perfect gold work in the majority of these cases.

Many labial and buccal cavities may also be satisfactorily filled with gutta-percha. A cavity for this material should have a general retaining shape, and consequently a little more cutting away is usually needed than for a white cement; but owing to the smallness of the cavities generally filled with

gutta-percha the preparation is as a rule rapidly effected.

Gutta-percha shrinks slightly, and in some mouths becomes dark on the surface. This change of colour is often accompanied by a softening and porosity of the surface. It is stated that varnishing the cavity with either copal ether varnish or resin dissolved in chloroform prevents the shrinkage of gutta-percha. Whatever may be the value of this varnishing, the fact remains that the majority of gutta-percha fillings, notwithstanding their leakage, save teeth remarkably well, as long as the filling remains fairly intact. Leaky gold fillings have little effect in saving teeth; why leaky gutta-percha fillings should not be open to this objection to the same extent is not satisfactorily explained. It is true that an explanation is to be found in the electro-chemical theory; but the teachings of the late Dr. S. Palmer in this respect have not been accepted by the profession at large.

For filling cavities (not too much exposed to mastication) where a clasp, or band, or part of a plate will be in contact with the filling and tooth, gutta-percha seems usually to answer better than anything else.

In manipulating gutta-percha, care has to be taken not to overheat and so spoil its durability. A

useful method of procedure is to simply warm the shank of the instrument just sufficiently to soften the gutta-percha when pressed on it. If a pellet is picked up with the end of a warm plugger, and at once conveyed to the cavity, a good deal of the softening may be made to take place while the pellet is packed. It is also often useful to hold the pellet in the cavity with an instrument in the left hand, and then further soften it and complete the packing with a warm plugger in the right hand. The idea is to work the gutta-percha satisfactorily with the least heat. It is principally a question of convenience and the size of the cavity, whether one or more pieces are used to fill it. If several pieces are used, it is advisable to work them somewhat on the non-cohesive gold principle. Sufficient heat to make one piece intimately cohere with another would in all probability injure the material. Large, medium, and fine pointed pluggers may be used as desired, and are all useful, the surface being finished by trimming and smoothing with thin flat instruments, heated just sufficiently for the purpose.

Combination of Filling Materials.—The combination of cohesive and non-cohesive gold has been alluded to, as well as combinations of gold and tin.

There are also several other combinations that are very useful on occasion.

Gold and Amalgam.—A combined filling of gold and amalgam is of value principally in approximo-occlusal cavities in molars and bicuspids. When the cervical wall is so far below the gum that the rubber dam cannot be carried over this border, or when this would be an inflictive procedure, the filling may be built up to the gum line with amalgam. This enables the dam to be applied, and a gold filling to be made. The amalgam should be trimmed as smoothly as possible, and then further smoothed and polished when it is set. There is no contour knuckle to interfere with the thorough smoothing and polishing of the amalgam, and discs can be freely used to effect this. When the exterior of the amalgam is polished the dam is applied, and the gold filling started by considering the amalgam as forming the cervical wall, and treating it accordingly.

In certain cases, no matter whether the cavity is far below the gum or not, the filling is built up to the knuckle with amalgam, and then completed with gold. A filling of this kind has often advantages over an all-gold or an all-amalgam filling. In difficult cases the tedium and uncertainty of packing the gold into the deeper parts of these cavities is done away with, and the part that

is made of gold is as easy of access, and can consequently be as accurately filled as an ordinary occlusal cavity. The gold top, or masticating surface, does away with the curled-up edges and chipping of margins that might take place if the filling were made wholly of amalgam, and the best properties of both materials are thus utilised. In making these fillings the gold may be packed directly on to the amalgam as soon as the latter is inserted; a matrix is generally used in order to prevent the amalgam from being forced out of the cavity or broken by the force used in inserting the gold. It is also a convenience, if not a necessity, to use a gold that will adhere to the unset amalgam; several makes of crystal gold will do this, and whichever is selected is generally used until it ceases to become amalgamated, and a sufficient layer of gold is built up; then the filling is completed with crystal gold, or foil, as preferred. The filling may also be started at the end of the occlusal step, or occlusal undercut, remote from the amalgam, and then gradually worked to, and over, the amalgam. It is possible, by proceeding in this way, and directing the force principally at right angles to the long axis of the tooth, to dispense with the matrix. The most convenient and generally satisfactory method is to build up the amalgam to the

desired height, and allow it to completely set before inserting the gold. Starting pits and grooves can then be cut in the amalgam, or a little non-cohesive gold worked in, and the filling then completed with cohesive gold. This also admits of the amalgam being so cut away that nothing but gold shows, and this is not so easy to exactly calculate when the filling is made at one sitting. The hard amalgam enables the gold to be more rapidly and freely manipulated, and does away with the delicate—not to say "finicky"—packing that is resorted to, to prevent the gold coming away from the partially set amalgam. As soon as gold is placed on freshly packed amalgam it absorbs the mercury, and this produces an extremely dry but unset and consequently friable amalgam. This necessitates the greatest care being taken in order to prevent the lifting or breaking away from the amalgam base of the first few layers of gold under the pressure used in packing.

When the gold has absorbed all the mercury it can take up, it will show its true colour, but it will then be difficult to make the next layer stick. Then again, an examination of these fillings a day or two after insertion will sometimes reveal a trench-like, shallow depression at the line of junction of the gold and amalgam, no matter how carefully

or with how much force the gold may have been packed into and onto the amalgam. This is probably due to the destruction of the amalgamated gold, for a filling of this kind made immediately really consists of three parts: first, an ordinary amalgam, then an amalgam composed principally, if not entirely, of gold and mercury, and finally a gold filling. In the first edition the writer advocated the "immediate" method of making these fillings, but now much prefers to insert the amalgam, and fill up with temporary gutta-percha, then, at a subsequent sitting, to insert the gold. When amalgam and gold are used in connection in the same cavity, the surface of the amalgam will become perfectly black, and for "appearance' sake" it is often advisable to cut out part of the buccal surface of the amalgam, and extend the gold, so as to cover up this part. It is said that an electrical action is set up which is beneficial in saving the tooth; no doubt the rapid oxidising and blackening of the surface of the amalgam is due to such action, but the action ceases as soon as the surface is oxidised, and beyond the preservative effect that a black amalgam seems to have, the value of these fillings is more mechanical than therapeutic.

It may not be out of place to here allude to the

electrical action that is caused by the presence in the mouth of two dissimilar metals. The generation of a painful electric current may take place when two dissimilar metals are in fairly close, but not absolute, contact; but the presence of moisture between the metals is required to bring it about. A gold clasp which impinges on an amalgam filling in a live tooth may cause pain, and two fillings, one of gold and the other of amalgam, in opposing teeth, may do so whenever the teeth are brought into contact, as the following case will show: the writer made a large contour amalgam filling in a pulpless upper molar; the opposing lower molar having a fairly large gold filling in its occlusal surface. The amalgam filling was trimmed free of the bite, but as soon as, and each time, the patient closed his mouth, he received a shock of pain in his lower molar. To at once remedy this, a small hole was drilled in the centre of the gold filling, and filled up with amalgam before the patient left the chair. He could then immediately close his mouth with perfect comfort. In the same way, if a gold clasp causes pain in a tooth filled with amalgam, a hole may be drilled in the amalgam and filled up with gold. These cases are comparatively rare, but the same experience may happen to any one whose teeth are sensitive, and whose gold fillings should

come in contact with the tinfoil wrapping of butterscotch. The writer has himself more than once experienced it when eating a piece of Roquefort cheese, the tinfoil of which had not been completely removed. There is no fear of electric shocks happening as the result of placing gold and amalgam in *absolute* contact either as fillings or compound gold and amalgam crowns.

Amalgam and White Cement.—It is often advantageous to line a cavity with cement, and then fill with amalgam. Pellets of a tough slow-setting cement may be placed against the walls, pressed to place, and the surplus removed; this forms a complete lining before the amalgam is inserted. The more usual practice is to place a thin mix of cement in the cavity, spread it against the walls, and at once insert the amalgam; using the latter as a buffer to properly form the lining, and press out the surplus cement. To do this is not quite so easy as it seems—the cement must be mixed just right. If too thin it will probably be all but completely pressed out, while, if it is too thick, it will be very difficult to press enough out of the cavity to produce clean, strong amalgam edges. It may easily happen that at one or more points the cement forms too thick a layer, and the amalgam is merely wrapped over what is practically a cement margin.

The operator, finding nothing but amalgam is visible on completion of the filling, thinks everything is right; but in a short time he finds that the force of mastication has broken the thin border of amalgam, and a broad line of cement has become exposed. This necessitates cutting out the cement at the border sufficiently deep to admit of proper repair with amalgam. Lining cavities is excellent practice, and efficiency is only attained by care and experience.

In certain cases the amalgam will be the better retained for the cement lining; shocks to the pulp also, from thermal change, will be to a great extent prevented, and should the amalgam shrink or curl up at the edges, the tooth will be better protected than if no lining were used. When, however, an amalgam is used that has the tooth-hardening, or preservative properties of copper, it is well for it to be in direct contact with the dentine. The use of a cement lining also prevents an amalgam from showing through a thin buccal wall, and consequently distinctly helps to preserve the appearance of the tooth; for this reason it may be useful in certain cases to place the cement only against the buccal wall.

Amalgam and cement are also combined by mixing together. Some advise the incorporation of

the alloy filings with the cement; others prepare the amalgam in the usual way, and then mix it with cement. Neither of these methods has given the writer any better results than the use of white cement alone, and the colour of these mixtures is about the same as an amalgam filling. In certain cases, however, there is great value in making a filling of cement and amalgam, and then covering the surface with the latter. The alloy is mixed with mercury in the usual way, and then part of it is incorporated with the cement during the mixing of the latter. About equal parts of amalgam and cement are used. This mixture is placed in the cavity, and the amalgam that has been left over is pressed into the mix, and the surface completely and fairly thickly covered. This method effects the retention of a durable filling in a cavity in which it could be retained by no other means. The mixture adheres to the dentine with great tenacity, and the amalgam adheres to the mixture far better than to cement alone. This method was suggested by Mr. F. A. Bellamy, and described by him in the *British Journal of Dental Science*, February 1887. Mr. Bellamy informed the writer that, although he usually presses the amalgam well into the mixture, so as to secure its retention, he finds that in cases where it is necessary to simply lay the amalgam on

as a veneer, the union is very good, and that, unless the filling has been strained by biting before it is set, the veneer will rarely break away.

Gold and Gutta-Percha.—A layer of gutta-percha may be placed at the cervical margin, and then the filling completed with gold. The writer has occasionally made use of this in cavities that were too far below the gum to admit of the use of the rubber dam until the filling was built up to the gum line. In some cases the result has been satisfactory, in others the gutta-percha has rotted; it is therefore only a method for occasional use: in all cases in which it would not spoil the appearance of the tooth, amalgam should be used in preference.

Gutta-Percha and White Cement.—This combination is useful in certain cases where a comparatively temporary filling is needed to preserve a tooth for a year or two as a preliminary treatment. It is principally useful in approximo-occlusal cavities in bicuspids and molars where the use of white cement is precluded owing to presence of moisture, and the rubber dam has to be dispensed with. The procedure is to fill up to the knuckle with gutta-percha, and complete with the cement. The better wearing properties of the cement under mastication protect the gutta-percha, and prevent its being rapidly worn away.

Gold and Cement.—It is a common practice to protect a pulp by flooring a cavity with cement, and then, when it is hard, to complete with gold. With the exception of occlusal cavities in bicuspids and molars, there is usually no room for this in live teeth. In certain large occlusal cavities some operators partly fill with cement, and press pieces of gold into it before it is set; then, at the same sitting, as soon as it is set, condense the projecting pieces and utilise them as so many starting points on to which to build. Care must be taken to have sufficient depth of cavity to retain the gold filling, otherwise it may come out. The writer finds this procedure is more trouble than it is worth, and would prefer to floor the cavity in the usual way, and then insert the gold. Certain operators spread thinly mixed cement over the interior of a cavity, and at once insert the gold. If this procedure could be easily and satisfactorily carried out, the filling would be akin to a gold inlay, with better margins, and would no doubt be well retained in cavities that cannot be properly shaped for gold. The writer has made a few of these fillings, but has no confidence in his ability to produce good results. In order to prevent the cement becoming mixed up with the gold filling, a base and lining of gold may be wedged to place, and the surplus cement will

then find its way out at the margins, and may at once be cleared away. It occasionally happens that an operator is tempted to fill a cavity with gold when the retainage is inadequate; the filling proceeds satisfactorily until the trimming process is nearly completed, when the filling comes out, or the patient may return in a few days with the filling in her purse. If it has been at all well condensed it may be replaced with a cement lining, just like an inlay; it will not only stay in place and give complete satisfaction, but will constitute an inlay with ideal margins. If the filling comes out before the polishing is finally completed, it may be finished at another sitting when the cement is completely set. The retention of a "gold-filling inlay," will be completely satisfactory, owing to the slight roughness of its interior surfaces, its close fit, and the manner in which cement adheres to metal as opposed to porcelain; and if one of these accidents occurs in a mouth in which there are several other gold fillings, it will be impossible to detect which is the filling that has been cemented in.

Separation of the Teeth.—In filling cavities on approximal surfaces, more especially if gold is to be used, it is necessary—particularly in the incisor

and cuspid region—to press the teeth somewhat apart in order to obtain room to work, and to admit of the filling being properly contoured. To separate the incisors make what is known as a "tent" of cotton-wool, using a tough variety of absorbent wool. Roll the fine end very tightly, and force it between the teeth. Keep the fine end outwards, then pull it forward with either the fingers or pliers, until the thicker part is tightly wedged between the teeth; finally cut off the protruding cotton-wool, back and front, with scissors. The small scissors with short slightly curved blades, that are made for trimming the cervical margins of gold crowns, are very convenient for this purpose. As a rule, the fingers are preferable to pliers for pulling the wool forward. With the latter too great pressure may result, and the teeth will become painful through too rapid movement. Manipulated with discretion, this method of using cotton-wool is convenient, answers all requirements, and rarely causes pain. If a wide separation is desired, this operation may be repeated every two or three days until sufficient space has been secured. If the edges of the cavity are ragged and cut the wool, they may be smoothed by passing a fine saw between the teeth. If the teeth are so close together, and so firmly set in the alveolar process that it is impossible to pass the

cotton-wool between them, a strip of rubber dam may be used instead, and on the following day the wool can be easily inserted.

In separating molars and bicuspids it is advisable to open, and, partly or wholly, prepare the cavities, and then to wedge one or more balls of cotton into them, and between the teeth. If the wool, instead of being packed into the cavities, is drawn between the teeth as in the incisors, it will be found that it works its way down into the triangular space at the necks, and sets up considerable irritation, without effecting any separation. It is often useful to saturate the wool with mastic, or sandarach varnish. This not only helps to stick the wool in place, but gives a more comfortable feeling to the patient's tongue, and also prevents the wool from becoming foul. It is generally better to saturate the wool with the varnish after it is placed in position in the incisors, while in bicuspids and molars it may, if desired, be saturated before its application. Some dentists after partially or wholly preparing cavities in bicuspids and molars, fill them with a gutta-percha—such as the red base plate—which expands somewhat, and by wedging it between the teeth, obtain gradually and conveniently a wide space. The objection to this, speaking

generally, is that it takes several months to produce the space, and patients are apt to forget all about it, and as long as they are comfortable, carefully avoid the dentist. The Perry separators are very useful instruments for immediately securing space in many cases. Used in the incisors, they are rather in the way, and if the approximal cavities in bicuspids and molars are large, extending down to the cementum, and well cut away at the sides to secure free margins, the points of these instruments will extend right into the cavities, and prevent them being satisfactorily filled.

To secure space immediately between the incisors, first apply a strong solution of cocaine to the gum on either side, and between the teeth; then trim a long stick of orange-wood to a tapering round point; soap it, and insert it between the teeth at their necks, pressing it steadily in until the patient flinches; then wait a short time, and press in still further, and again stop; now firmly press in as far as possible, using considerable force. The object of using a long, and preferably a thick stick, is to admit of its being readily grasped in applying the pressure. Never hammer a wedge of wood between the incisors, the shock of the blow is most disagreeable.

Much greater space is usually needed for porcelain inlays than for any other method of filling teeth, and this can usually be obtained with cotton-wool, applied in the manner already described, and reapplied until the desired separation is effected.

CHAPTER V

PORCELAIN INLAYS

Of late years this method of filling teeth—for inlays may certainly be regarded as fillings—has come to the front in no uncertain manner, owing to a great extent to the invention of small, convenient, and reliable furnaces; but perhaps still more to the invention by Dr. Jenkins of a thoroughly reliable, low-fusing dental porcelain, and the very complete manner in which he has worked out and described the whole method of manipulation.

So much has been written on this subject that it is unnecessary in these "Notes" to do more than briefly allude to certain points connected with it.

It seems hardly correct to say that the margins of a cavity properly prepared for an inlay should not be bevelled; rather should it be laid down that the enamel border should be cut in the same plane, or at the same angle as the dentine; in other words, that the walls of the cavity may slope outwards from the floor, and that a general bevelling of the walls of the cavity is permissible, but that any

bevelling of the margin that places the enamel border at a different angle to the walls (as in cavities prepared for gold filling) must be carefully avoided. The floor of the cavity and the lines of junction of the walls and the floor should be rounded, and the whole cavity be so prepared that the matrix or mould can be easily removed without distortion. This usually means an entire absence of undercuts, and a general sloping outwards of the cavity walls. A smoothly cut, well-rounded undercut may, however, be made with advantage in certain cavities where, owing either to absence of a wall, or much sloping of an opposing wall, the matrix can be cleanly removed without distortion. For instance, if the cutting edge angle and much of the lateral walls of an incisor, or canine, are missing, a good deep undercut at the cervical wall is not only desirable, but often essential, for the retainage of the inlay. In a case of this description the matrix can be withdrawn in the direction of the cutting edge, and will perfectly retain its shape.

The edge of the cavity should be as clearly defined and sharp as possible, for on the clear distinctness of the margin depends the production of a fine margin on the matrix, and on the clean margin on the matrix depends the excellence of the joint when the inlay is cemented to place. To

obtain these fine cavity margins is one of the most difficult steps in the whole proceeding. Very sharp burs should be used for preparing the cavity, and the small stones known as the "Gem Cavity-Trimmers" are very useful for producing clean-cut margins. Diamond burs and Arkansas stones are also of great value. Ample separation of the teeth is necessary in approximal cavities, and labial walls may be freely cut away when necessary to facilitate the operation. The secure retention of an inlay greatly depends on the cavity having a certain depth, but there are many cavities, particularly large approximal ones in incisors and canines, in which the absence of a great part of the lateral walls produces a shallow cavity that cannot be deepened without cutting into the pulp, and it may not be desirable to destroy the pulp in order to deepen the cavity.

It may be said that any cavity that will retain a cement filling will retain an inlay, providing the inlay itself can be sufficiently grooved or undercut to hold in the cement. Large restoration of contour in shallow cavities will usually demand a good cervical undercut, and a general preparation that will enable this undercut to be taken full advantage of. It may also be necessary—particularly in the restoration of cutting edge corners—to remove part of the cutting edge at right angles to the long axis

of the tooth, so that a step is produced that will effectually prevent the inlay from being tipped out by the force of mastication. When it comes, however, to this, the thickness of the cutting edge restoration must be considered. The breaking strain that the porcelain is likely to be subjected to must be observed, and the propriety of an inlay, a gold restoration, or a crown determined on, as the judgment of the operator dictates.

Whenever the cutting-edge corner of an approximal cavity in an incisor or cuspid has to be restored, it is claimed that the porcelain cores invented by Mr. W. F. Mellersh not only effect considerable saving of time, but greatly facilitate and improve the operation. In the *Journal of the British Dental Association*, July 1902, Mr. Mellersh writes:—

"After investing, the floor of the matrix should have sufficient body baked into it to fill the deeper portion, but not to show any contour. Over this a quite fluid mix of body and alcohol is laid, and the porcelain tip wetted with a little of the same by being rubbed over the palette with a pair of conveying forceps. The tip is set gently in place in the matrix, care being taken to ensure that its edge is square with the cutting-edge of the tooth—as shown by the impression in the foil—and that its

anterior portion is in the proper plane. After burning off the alcohol, the tip is fused in place, and the inlay rapidly completed: there is no danger of the porcelain moving during subsequent firing."

Since then, these specially made pieces of porcelain, to which the name "Porcelain Inlay Cores" has been given, have been improved in sizes and shapes until they may now be said to fulfil all requirements in this respect. Dr. Jenkins of Dresden, to whom the manufacturers submitted them during the time they were perfecting them, expresses himself as highly satisfied with them, and considers them a very valuable invention. The merits of these cores may be thus briefly described. The contour and corner is built up and restored more easily, more rapidly, and more accurately. A sharper or better defined corner can be produced, and the resulting combination of the core and the Jenkins' porcelain enamel produces—according to Dr. Jenkins—a restoration that is "immensely stronger than can be made with any high-fusing porcelain."

Mr. Mellersh points out that "owing to a difference in the fusing point of the core and of the porcelain enamel, careful annealing at every stage is essential." Very gradual raising of the heat to the fusing point of the Jenkins' enamel is essential, and equally important is a gradual cooling down in the

furnace, if satisfactory results are to be obtained. A neglect of these precautions will be likely to cause the inlay to crack alongside the core.

Whenever an inlay is subjected to the force or pressure of mastication a certain thickness of the porcelain is needed, and just in proportion to the shallowness of the cavity, so is an undercutting or grooving, and consequent weakening of the porcelain, demanded in many cases. The matrix may be made of gold or platinum, although gold is only applicable to a low-fusing porcelain. Gold can be more easily adapted to the cavity than platinum, and one of the advantages of the Jenkins' porcelain is that it can be fused in a gold matrix. Platinum can be successfully used, but its accurate adaptation demands a great amount of skill, time, and patience. It must be frequently removed from the cavity and annealed during its adaptation, and fine margins are only secured by much patient burnishing. The platinum is gradually adapted, "little by little," so to speak, removing and annealing almost continually. The platinum that gives the best results is $\frac{1}{1000}$ of an inch thick, and as soft as platinum can be made. The extreme of softness can be obtained by covering up the platinum with unslaked lime, and thoroughly heating it in a furnace or with a blow-pipe.

The rigidity of platinum compared with gold, and its ability to stand great heat without warping, are its advantages. A platinum matrix is not so likely to be distorted in removal from a cavity, and in very many cases there is no necessity to invest it. The probability is that any one who can make a perfect matrix with platinum will prefer that metal to gold; but it is equally probable that few men who appreciate the Jenkins' porcelain will take the trouble to acquire skill in the use of platinum, and of those who do give platinum a fair trial, only a small proportion will obtain as good results as they are able to do with gold. Platinum is manipulated in the same manner as gold, except that the former requires more frequent removal and reannealing, and a more thorough and prolonged use of the burnisher.

Williams' No. 30 gold-*foil* is generally preferred for inlay work. The makers of this foil have recently brought out a gold specially prepared for inlay work, to which they have given the name of "Crescent Gold"; though styled No. 30, it is thicker than the No. 30 foil, the thickness of which is about $\frac{1}{2000}$ of an inch. By reason of its thickness, it is easier to pass beyond cervical margins than the thinner foil, and it can also be removed from a cavity with less chance of distortion, but it is not so easily adapted to the margins unless a burnisher

is used, and to a greater extent than the thinner foil requires. It is specially valuable when, owing to comparatively slight separation, the matrix has to be very carefully teased out from between the teeth, and in many large cavities it will obviate the necessity for filling the matrix with wax to prevent distortion.

The manner of adapting the matrix by means of pieces of amadou, or by means of balls of wet cotton-wool; and the improvement of the adaptation by then using pieces of chamois-leather, and finally perfecting the margins with a burnisher, if necessary, are well known. In finally burnishing the margins, the matrix may be held in place—to prevent rocking—by means of a strip of rubber-dam tightly stretched over the side of the tooth, or a piece of wet silk ribbon may be used.

In applying the burnisher for perfecting margins —and this is particularly necessary if there are any little folds or creases at the margin—it will be found that its use stiffens the matrix, and renders it somewhat springy. Burnishing at one part, may cause a lifting of the matrix at another part, and no amount of all-round burnishing will correct this. The strip of rubber-dam, or the silk ribbon, will prevent this to a great extent, but as it is usually necessary to clearly see the margins, in order to accurately

smooth them, the use of the strip is generally a subsequent or final proceeding. It is therefore often advisable, after having burnished as accurately as possible, to remove the matrix, anneal and re-apply it, and make the final adaptation with amadou, or balls of wet cotton-wool. The strips may then be again used to compress and finally perfect the margins. The burnisher should not again be used unless absolutely necessary.

A platinum matrix can be annealed in a Bunsen burner, or, better still, in a very hot electric furnace. A gold matrix should be placed on the electric annealer or on a sheet of mica or platinum over a spirit-lamp. Great care should be taken in re-applying an annealed gold matrix in approximal cavities, for the gold is now so soft that it may be crumpled up in passing it between the teeth, and rendered useless. Many operators find pieces of rubber, fixed in suitable handles or mandrils, of great use in perfecting margins. Mr. Rippon makes considerable use of the indiarubber corks that are supplied with small bottles, and finds them convenient to use for this purpose without mounting them in handles.

In some cases when the adaptation of the matrix —especially in regard to the margins—is difficult or uncertain, a thin mix of the inlay body may be

painted over the interior of the matrix, and fused so that it is lined with a thin glaze. This stiffens the matrix, and it can then be placed back in the cavity, and re-adapted. The thin glaze will break or crack at certain parts during the re-adaptation, but sufficient will remain intact to hold the matrix more firmly in place during this final adaptation, and a more perfect mould will result. If a gold matrix is used, it should then be invested. Any overlap that would interfere with the removal of the matrix should be cut off with a lancet or other suitable sharp instrument before it is removed. It is usually necessary to invest a gold matrix, not only to prevent warping of the metal under heat, but also to permit of its being easily handled without distortion. It is a question whether the shrinkage of the porcelain has anything to do with distorting the matrix. Two kinds of shrinkage take place. One is the running together of the powder during fusion, and the consequent obliteration of the numbers of minute spaces that existed between the particles of powder. The other is the probable shrinkage of the fused mass during cooling. It is doubtful if any appreciable shrinkage takes place in the fused mass when used in such small bulk as inlays. When the particles of powder run together during fusion, the

mass usually readily leaves the walls of the matrix at one or more points, and does not in any way drag the wall with it, and careful painting around the wall and fusing in successive layers prevents the body leaving the walls. There is, however, a warping of the porcelain that takes place if it is fused in a certain form. If a long, fine-pointed cone is made, and fused in a horizontal position, it will be found that the apex of the cone turns up; also if an inlay is made for a fairly large approximal cavity in an incisor that tapers in a V-shaped manner from a broad cervical margin to a shallow almost pointed apex at the cutting edge, it will, if made in an uninvested gold matrix, curl up at the cutting edge and rock in the cavity so as to be a bad fit. The same thing may occur if very thin platinum is used, though not to the same extent. If, however, the cavity is practically a round hole of fair depth, with supporting walls of equal height, the inlay, if made in an uninvested gold matrix, will rarely show signs of warping. The same kind of warping will take place if the whole of the labial wall of a fairly large incisor cavity is completely removed, leaving only lingual, cervical, and cutting edge walls. In this case, the matrix being entirely unsupported at one side, will warp or shrink away from the

cutting edge wall. Whether this is partly due to a warping of the porcelain on cooling, drawing up the matrix, or whether it is solely due to the heat warping the matrix, the writer cannot say, but the fact calls attention to the value of having a good overlap of the matrix at these parts, and so covering up the overlap with the investment that it is held firmly in place. Some dentists endeavour to prevent warping by breaking up old artificial teeth into small pieces, smearing these pieces with thinly mixed body, and placing them in the matrix. Thinly mixed body is then placed in the matrix, so that all the interstices between the pieces of broken-up teeth are filled up. The porcelain on fusion unites everything together, and the contour is then built up in the ordinary way. This method, for a knowledge of which the writer is indebted to Mr. Charters Birch, seems to be of value principally in non-invested matrices of a certain shape, for a well-invested matrix will be found to rarely change its shape.

Dr. Jenkins recommends an investment of powdered asbestos and water, and this will be found the most satisfactory material to use, provided it is the right kind. The investment must be dried with heat, as, unlike mixtures of plaster of Paris and marble dust, &c., it does not set in any

reasonable time if left alone. In order to save time it has been suggested that the asbestos should be mixed with alcohol, and then the alcohol set fire to and blazed off. This, however, produces a much more friable and more easily damaged investment than if water were used, and as an investment of asbestos and water can be completely dried in five minutes if necessary, there is only a saving of about three or four minutes in using alcohol, and if the alcohol investment is accidentally dropped on the floor it flies all to pieces. It also happens that unless great care is taken some of the more friable alcohol and asbestos investment may be rubbed off and become mixed up with the inlay body. The writer is indebted to Mr. T. M. Mitchell for the method of rapidly drying the investment, which is as follows:—Place the tray containing the invested matrix on a stand over a spirit-lamp. (The lid of a small tin box on two improvised uprights will serve the purpose.) The flame at first must be very small. Prick into the investment every now and then with a probe or an old excavator, so as to allow the steam to escape, and as soon as the investment becomes sufficiently dry to admit of it, scrape two small holes in it, one at each end of the tray between the matrix and the edge of the tray. At first the holes will fill up as soon as

they are made; in a little time they will remain open, and should be scraped so that they are free to the bottom of the tray. Then turn up the flame so that the drying is rapidly completed. The writer has carefully timed himself on several occasions, and finds that it can be satisfactorily accomplished in five minutes. As soon as the tray is removed from the stand and cooled the inlay body is placed in it, and at once placed in the furnace. Even if the furnace is hot the investment will remain intact. There is no necessity to dry as rapidly as this unless time presses, but this method is very useful on occasion, and in the writer's hands has proved more satisfactory than the use of alcohol.

Whether alcohol or distilled water (with or without the addition of gum-tragacanth to the water) is used for mixing with the inlay body is principally a question of individual taste and manipulation. The alcohol mix can be placed in the furnace at once, and the alcohol will catch fire and blaze off without any disturbance of the body. A partially dried alcohol mix will, however, blow all to pieces. A water mix must be completely dried before it is placed in the furnace, to prevent its blowing up through generation of steam. This careful drying takes a little time unless pieces of blotting-paper are applied to first remove as much moisture

as possible. By drying with blotting-paper the body shrinks or settles down better in the matrix, and more can then be added. By this means the matrix at each fusing contains more body than if alcohol is used, and the number of firings is reduced. It is easier to paint to a smooth surface if water is used. It is also more difficult to prevent the mix slopping over the margins, and this leads to much careful scraping away of the overlap and much careful brush-work to paint back to an exact margin, with a probability of not always painting back far enough, and consequently producing an inlay with raised edges. Equally good results can, however, be obtained with either water or alcohol. Those who have the electric current laid on generally prefer an electric furnace, though a gas furnace answers equally well; reliable gasoline furnaces are now made, but at the present time they seem to be better adapted to high-fusing bodies. The advantages of an electric furnace are the absence of noise, odour, and heat radiation, and the fact that no bellows is required, as with gas furnaces. An electric furnace may be used in the operating room, or even in a drawing-room, without the slightest inconvenience to any one.

The small Mitchell Electric Furnace (Fig. 11) is generally used in this country, and is a very

convenient furnace for fusing the Jenkins body; there is some risk of over-fusing in it when the main current is on full strength, as the heat consequently runs up too rapidly. It is necessary, under this condition, to watch the work as "a cat watches a mouse," and take the tray out of the furnace immediately the body is sufficiently fused.

Fig. 11.

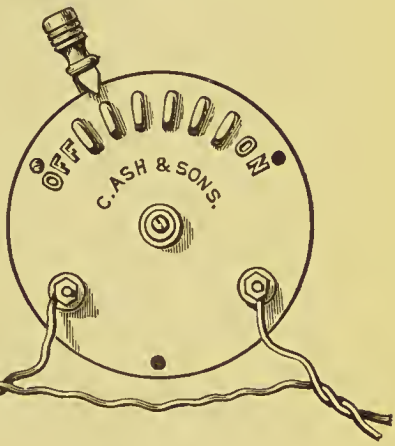

Fig. 12.

The heat can be regulated somewhat by gradually drawing the tray towards the open door of the furnace, but all difficulty is overcome by using the small Heat Regulator (Fig. 12) that is now supplied. In many cases, after the furnace has been well heated up, and the current is strong, the whole of the fusing can be done with the indicator pointed to one from full; but if the heat is not great enough for this, the inlay may be nearly fused at full, and

then the indicator turned back one point, so as to get rid of the increased heat that so often follows switching-off the current when complete fusion is reached; sufficient heat will remain to safely complete the fusion. If necessary, the fusion may be observed with a magnifying-glass. The Heat Regulator is considered to prolong the life of the furnace by lessening the number of "burns out." The Jenkins gas furnace, while permitting an exact regulation of heat, and enabling one to easily carry out Dr. Jenkins' directions as to fusing—viz. to bring the heat up to the point when fusion begins, and hold it there until the fusion is completed—has the disadvantage of necessitating a cover for the tray in which the inlay is fused. The small opening in the side of the tray through which the fusing is observed renders it somewhat difficult to see exactly what is going on. This is particularly the case on dark days, or if an inlay is made in the evening. Many dentists—especially if they have keen eyesight—find the Jenkins furnace answer their requirements perfectly. The Dall gas furnace is so constructed that the flame never enters the muffle, and consequently no covering up of the tray is needed.

The best-fused dental porcelain is obtained by gradually and slowly heating up the body until the

melting or fusing point is reached, and then, if possible, keeping the heat at this point until the desired degree of fusion is attained. To place an inlay, or any other dental porcelain work in a red-hot furnace, or to attempt to save time by bringing up the heat as rapidly as possible, is a mistake. There is, however, no necessity to slowly cool an inlay. Whatever may apply to porcelain crowns, where the pins of a plate tooth, or a platinum band or post have to be taken into consideration, or to a porcelain bridge that is fused around a bar, or connected with metal attachments, does not apply to an inlay which may be removed from the furnace as soon as it is fused. It is usually advisable to stop just short of complete fusion during the several bakes, until the work is placed in the furnace for the last time. Slowly cooling down seems only necessary when an inlay *is fused around a porcelain core or other piece of high-fusing porcelain.*

The colour of the Jenkins inlay, judging by the sample shades, is not quite so "tooth-like" as the higher-fusing bodies, but it is good enough for all practical purposes, as it is not so much a question of exactly matching a tooth, as producing a match or blend that defies detection at ordinary speaking distance. There is often a wide differ-

ence between the appearance of an inlay when the lip is lifted up and it is closely inspected, and its appearance at a greater distance, with all the lights and shadows playing on it momentarily, varying with the movements of the lips. Careful blending of the various shades will give an artist an advantage over a merely skilful workman, and it may be suggested that the use of two or more shades fused in separate layers, one over the other, may give better results in some cases than a mixing together of the shades before fusing. The removal of the matrix from the porcelain is usually easily effected. The small, straight Boley pliers or tweezers are very useful for stripping off the gold. The straight points enable a good broad grip to be obtained at the edge, and the gold or platinum is then gradually and satisfactorily turned back from the margins, until it generally comes off in one piece. A slight feather edge will often be found on the inlay. This is easily removed with a partly worn fine cut plug trimming file (a Smith's disc), or it may be rubbed off with one of the small engine stones (a "Gem Cavity Trimmer") held in the hand. Some operators use either a small stone, or a sandpaper or cuttle-fish disc in the engine. It is safer to use a hand instrument, to avoid removing any of the true margin.

The retention of the inlay by means of the cement will greatly depend on the form and depth of the cavity. Cement adheres to dentine better than to porcelain, and it is therefore of more importance to groove or undercut the inlay, than to groove or undercut the cavity, although a double undercutting both of inlay and cavity is often desirable. The simplest means of enabling the cement to grip the inlay sufficiently to hold it in place, is to merely remove the glaze from the interior surfaces of the porcelain. This is effected by covering the exterior surface and margins with wax, and then applying hydrofluoric acid until the glaze is removed from the whole of the exposed porcelain. It was pointed out by Dr. George Evans (*Dental Cosmos*, January 1902) that this can be more easily and quite as effectually obtained by means of a diamond drill in the dental engine. If a watchmaker's eyeglass is used the drill can be easily and accurately applied until the glaze is completely rubbed off, and the surface etched all over close to, but not quite up to, the margins. The writer makes frequent use of this method, and finds it a thoroughly practical proceeding.

Dr. Jenkins cuts a groove all around the inlay with a diamond disc in such a manner that a distinct and fast-holding stud is formed. Mr.

Wolfenden cuts a good groove all around near the margin—but at a sufficiently safe distance—and then cuts a number of grooves running from the original groove round the bottom of the inlay and up to the original or main groove again. These grooves are made in opposite directions, so that the inlay (with the exception of a slight space near the margin) is covered with a number of criss-cross cuts or grooves. It may be mentioned that the smallest size of diamond discs is the most convenient, and that they should be kept well wet during use. As soon as a disc ceases to cut easily and rapidly it should be discarded, or sent to be recharged with diamond dust.

When the cavity is shallow, and there is, consequently, difficulty in grooving the sides of the inlay, some operators cut two grooves into the floor or bottom of the inlay as far apart as practicable, and then grind out the porcelain between these grooves. The angles formed by removing the porcelain between the grooves are then deepened and laterally extended into undercuts, so that a space with dovetail ends is produced.

Mr. Charles Rippon has devised a very ingenious and original method of retainage, which consists in embedding a small mass of silex in the inlay in such a manner that its subsequent removal pro-

duces a distinct undercut cavity in the base or bottom of the inlay. This method is the outcome of many experiments, made with the object of improving the retainage of porcelain inlays, and has given the inventor the greatest satisfaction in his practice. The procedure, which has been demonstrated by Mr. Rippon on several occasions at dental meetings, is as follows: A tray filled with dry, finely powdered silex is placed in the furnace, and heated up until some of the particles of the silex are found to have formed themselves into small ball-like masses of various sizes. These little balls are readily picked up with a small sable brush that has been brought to a fine point by twisting it between the lips. The matrix is first thinly painted over with a thin mix of the inlay body, which is fused so that the interior of the matrix is completely covered or lined with a thin glaze of the body. It is then about half-filled with a stiffer mix, and a hole is made in the centre with the brush. In making the hole the body is swept up to the sides in such a manner that it goes up to the margins, and the matrix is thus filled, with the exception of a central round or oblong cavity, which must extend to the floor, and leave the thin glaze produced by the first fusing exposed at the bottom of the hole or cavity. If

during the manipulation of the body to make this hole it is found to be too wet, blotting-paper should be applied until sufficient moisture is absorbed to enable the body to be properly and easily manipulated. One or more of the little balls of silex is then picked up with the point of the brush, and placed in the cavity that has been made in the inlay body until it is filled up to the right height, care of course being taken not to build up the silex too high. In large inlays that admit of a large central cavity, the balls of silex may be gently patted down with an instrument, so that they crush up into a more even mass. In very many cases, merely placing the pieces of silex in exact position with the brush is all that is necessary or advisable. The body is then fused, and this will leave some of the silex projecting, owing to shrinkage of the body. A fairly stiff mix of the body is then carefully placed round the margins of the matrix, and carefully worked from the margins towards the centre and over the silex. The object of this is to fill up the matrix and cover over the silex without disturbing the latter. Another fusing will perhaps still leave the top of the silex exposed; the same procedure is resorted to until it is completely covered or embedded in the fused inlay. Then the contour is built up, and the inlay completed in the usual way. When the

matrix is stripped off, the thin film of porcelain that covers the silex at the bottom of the inlay is readily pierced and broken away with a steel point or an excavator, and the silex is easily removed with a damp brush. Mr. Rippon uses a platinum or platinum-gold matrix without investment. He places the matrix on a tray filled with powdered silex, and consequently the fusing of his inlays produces the little lumps in the silex that are utilised in this process. He mixes the inlay body with distilled water, in which gum-tragacanth is dissolved. This method is by no means difficult if all the various details are grasped, and as its success depends on this, the writer has endeavoured to describe it as fully as possible. Whenever the case will admit of it, Mr. Rippon cuts a depression in the floor of the cavity in the tooth, corresponding to the hole in the inlay, and also undercuts the depression in the tooth. The writer finds that although this is an extra precaution which is doubtless very valuable in certain cases, that the hole in the inlay provides excellent retainage when no corresponding undercut can be made in the tooth. It is desirable for the film of porcelain at the base of the inlay to be sufficiently broken away to provide a fairly broad or wide opening, although whether the hole in the inlay is undercut or

not greatly depends on the extent to which the base is broken away. A deeply undercut hole is not necessary. It stands to reason that the formation of a good retainage cavity in the base of an inlay depends on a sufficient depth of cavity to admit of a reasonably thick inlay being made. In shallow cavities where the inlay is so thin that no retainage can be made in the porcelain, either by means of a hollow in its base or by means of grooving the sides, Mr. Rippon has devised another method, which he finds most useful. He places the piece of foil with which the matrix is made between folds of fairly coarse sandpaper. By means of forcibly rubbing the sandpaper, and by striking it with a hammer, the foil is thoroughly well roughened and indented. The matrix is formed with the roughened foil in the usual way, taking care to only apply a burnisher to the margins. The inlay fused in the roughened matrix is found on stripping off the foil to have a roughened and indented surface which provides as satisfactory retainage as can be secured in these shallow cases with no weakening of the inlay.

In mixing the porcelain powder with either alcohol or water there is no necessity to use a spatula; a camel-hair or sable brush is all that is necessary. A spatula may be used to just "dab"

the powder and liquid together, but any vigorous rubbing with a metal spatula must be avoided, for this is likely to change the colour of the inlay. The writer, by vigorous use of a pure nickel spatula, has produced some almost blue-black inlays. Platinum vigorously used will make the inlay from a dirty grey to a slate colour, while pure gold will produce a pink shade.

In placing the inlay body in the matrix there are several typical methods. One is to build up to exact contour each time, filling up all spaces and depressions caused by shrinkage during fusion. Another is to fill up to contour, but keep the margins free, and then, after filling up all spaces and fusing to a fairly even level, to build up high in the centre and allow the heaped-up body to flow down to exact contour and up to the margins. A third way is to paint a very thin mix evenly all over the matrix, just up to the margins, and fuse this. The matrix is thus covered with a thin film of the fused body. Another thin layer is applied and fused; then the matrix is filled in a concave manner, and the body fused. This goes on, always painting from the centre up to the margin, until the inlay is level with the margin. Contour is then gradually built up and fused layer by layer until the inlay is completed. The first method means that care has

to be taken in accurately filling up spaces, and if small, deep, trench-like depressions are formed near the margins, it is troublesome to fill them up and secure clean margins.

The second method demands an accurate calculation of how far the heaped-up body will flow down without producing plus contour, and it also demands a long-continued fusing at just the right heat to prevent over-fusing.

The third method does away with the production of trenches or spaces that may be troublesome to fill up. It enables the margins to be kept in view all the time. If any of the body is allowed to flow over, it will only be at certain parts, and a painting back to an exact margin is easy. The whole work proceeds gradually, layer by layer, and exact margin and exact contour are assured. This method demands a considerable number of fusings, but the inlay grows gradually in a thoroughly well-defined and accurate manner. Fusing to a biscuit bake until the final fusing, is frequently recommended, but this often causes the body to shrink considerably when completely fused; whereas if the inlay is built up carefully, layer by layer, the first two linings may be fully glazed, and every other fusing brought to a rough or slightly wavy glaze until the last layer is applied. When this last layer is fused

to a full glaze, it will be found that the inlay is completed just as it was wanted to be. Whatever may apply as to carefully biscuiting high-fusing bodies, there is no need to stop short of a wavy or rough glaze with the Jenkins body.

Careful experiments have proved that the Jenkins porcelain is one of the strongest, if not the strongest, porcelain that can be used for inlays. Over-fusing the Jenkins porcelain and the consequent burning out of the colour, and production of a porous, friable material, is merely a question of carelessness or want of experience. As a matter of fact, it is far easier to watch the fusing of Jenkins low-fusing porcelain than any of the higher fusing bodies. The intense heat required with high-fusing bodies renders it difficult to see what is happening, and as every kind of porcelain must have an exact "fusing-point," beyond which it is detrimental to proceed, the probabilities are that the necessity for accurately fusing Jenkins porcelain in order to maintain the colour, will lead to the production of a more perfectly fused and consequently stronger porcelain—quite apart from any intrinsic merit that it may possess—than can be obtained with a high-fusing body that cannot be so carefully watched.

The exact place that porcelain inlays occupy as regards their durability and tooth-saving properties

is not yet accurately determined. The retention of an inlay in a cavity will depend on the consideration of many things, and most failures will be overcome by experience. There is every probability, however, that the original idea that these inlays could be satisfactorily placed in almost any kind of cavity from which the decay was removed and the margins smoothed, to the great benefit of excessively nervous and sensitive patients, will have to undergo some modification. Depth of cavity is now being considered as a *sine qua non* of success, but it has been pointed out that in many cases depth and pulp preservation cannot be secured in the same cavity. The fact that some inlays come out should not prejudice any one against this method. All kinds of fillings have "come out," and methods of preventing this with other materials were not arrived at "in a day." The same applies to crown work and to bridge work. The fact that a crown or a bridge becomes loose merely stimulates investigation of right principles. Decay may take place at the margins of an inlay. This has, however, been known to occur at the margins of any kind of filling, and maintenance of integrity of tooth-structure at the margins of inlays must be considered in its relation to other fillings.

The writer's experience with the white cements

leads him to consider that maintenance of integrity of margins (meaning resistance of margins to decay) will principally depend on the preservation of the cement joint. The closer the fit of the inlay the less chance there is for particles of food to collect in the disintegrated joint, and the probabilities are that the closer the joint the less rapidly the cement will be dissolved. The writer has seen cases where decay has rapidly attacked the margins, but this was due to the overlooking of a defect in the enamel near to the margin. He has seen exactly the same thing with gold fillings. As an illustration of this, he may say that he inserted a contour gold filling in an upper bicuspid, the margins of which were well extended for prevention. Six months afterwards a pin-point cavity of decay was discovered near the cervico-palatal angle. This decayed point was close to the enamel margin of the filling, but had not extended to the filling. The decayed part was cut out, extended to the filling, and filled. In another six months an exactly similar point of decay was found midway between the cervical and occlusal margins, also on the palatal side. This was cut out, extended to the filling (it was close to the filling, but had certainly not commenced at the margin), and filled. Here are two causes of failure, both on the same side of the filling,

that, owing to their original minuteness, escaped notice when the main or original filling was inserted. The margins of this cavity, when prepared for the filling, were clean and showed no defects, and yet, if this patient had not come up for regular inspection, a failure of the filling would have been attributed to imperfect work, or incompatibility of the material with tooth-structure. The same thing would have happened if the tooth had been filled with an inlay, or with any other material. The possibility of similar occurrences has been brought before the profession by Dr. Leon Williams. His microscopical examinations show that there is always a possibility of the beginnings of decay, and sometimes a considerable amount of penetration existing that is not apparent to the naked eye of the most careful operator. Inlay work, however, demands the most careful preparation of margins that it is possible to make, and, in the great majority of cases, nothing but a collection of food deposits in a marginal trench produced by wasting away of the cement is likely to produce failure through decay. It is therefore a question of experience whether a sufficient wasting away of the cement takes place to cause recurrence of decay in a thoroughly well-fitted inlay. The experienced experts say that a superficial wasting occurs, but that afterwards the

wasting either ceases or is extremely slow. We hear of dentists who fit their inlays so perfectly that no trace of cement can be found in the joint. It seems difficult to understand how the wasting away can be observed in cases where the joint is so close that no cement can be discovered on the completion of the operation. The extraordinary penetration of fluids into an *apparently* perfectly close joint is sufficient to make one expect a dissolving out of the cement, no matter how fine the line of cement may be, but the practical resistance of the fine line of cement, and the resistance of the slowly produced and infinitesimal space to the collection of food stuffs in sufficient quantities to cause decay more rapidly than with other so-called permanent materials, is something for the future to determine. The probabilities are that porcelain inlay work will depend for its permanency as a tooth-saving method, or material, on judgment and skill, and that it will hold its own as a permanent method with the best of the permanent, or so-called permanent, methods and materials that we have at our command. And assuming an average of permanency in suitable cases, it possesses the saving grace of beauty, which is alone sufficient to make one strain its durable properties to the fullest

extent, and to even excuse one for unduly straining them.

Infinite care and the closest attention to detail are demanded of the inlay worker if he desires to accomplish good results. No one who has not the capacity for "taking pains" can hope for success in this work.

Harvard cement is generally preferred for setting inlays. This cement can be mixed somewhat thicker than many other cements without interfering with the accurate placing of the inlay in the cavity. The consistency to which the cement should be mixed can only be determined by experience. If too thin it will be too weak; if too thick the inlay cannot be pressed into exact position. In many cases the inlay will be found to "spring back" after it is pressed to place. This must be looked for, and, if necessary—as it usually is—gentle pressure must be applied by means of a suitably trimmed stick of orange wood or hickory, until the cement has lost its elasticity. From three to five minutes is usually sufficient for this. A piece of linen tape is very useful for accurately pressing an inlay to place, and at the same time wiping the surplus cement from the margins. In some cases the inlay may be securely tied in place by wrapping floss silk several times round the tooth. In many

instances it will be found difficult to tie the inlay in place without disturbing the accuracy of the fit. Judging by what is left on the mixing slab, Harvard cement, when mixed for setting inlays, does not become hard under from one to two hours—depending on the mix—and the maximum of hardness is not even reached then. The patient must therefore be warned not to use the teeth in mastication for a certain time after the inlay is cemented in place. This cement is not hydraulic —that is to say, it does not set properly in the presence of moisture. It must therefore be protected with a sufficiently thick film of varnish or other suitable substance that will remain in place for some hours. It seems an unnecessary infliction—except, perhaps, in exceptional cases—to keep the rubber-dam in place for an hour or two, even if the annoyance is minimised by cutting the greater part of it away, and tying the remainder into a kind of little bag that encapsules the tooth. A small agate pestle and mortar will be found very useful for remixing any surplus of mixed inlay body that has become dry. An ordinary watchmaker's eyeglass (No. 4) will be of great assistance to many in accurately placing the inlay body in the matrix, and painting it to exact margins.

CHAPTER VI

TREATMENT OF DISEASED CONDITIONS OF THE TEETH PREPARATORY TO FILLING

Sterilisation of Cavities.—Microscopic examination shows that even when the whole of the soft dentine is removed there is a certain amount of apparently hard dentine left into which microbes have penetrated. The most thorough preparation of cavities is insufficient to completely eradicate this except perhaps in very small cavities that have to be greatly enlarged in every direction to admit of being satisfactorily filled. It is considered that these microbes may live under a perfectly tight filling, and that they may gradually find their way to the pulp, and cause it irritation and perhaps death. Dr. Choquet, who has made exhaustive investigations in this connection, thoroughly and completely sterilises the cavity by drying it, removing the decay, drying the dentine with warmed air and 70 per cent. alcohol, followed by absolute alcohol and hot air, and then applying a mixture of alcohol, xylol, geranium

essence and hydronaphthol. By this means not only soft dentine but hard dentine may be completely sterilised (*Journal of the British Dental Association*, September 1901). The writer has been informed that this is a somewhat painful process, and that for practical purposes the sealing of a suitable germicide in the tooth for from twenty-four hours to a few days will give sufficiently good results.

For many years the writer has been in the habit of sealing up a paste of tannin, carbolic acid, and oil of cloves in cavities, preparatory to filling them, because he found that this dried up and hardened a layer of soft dentine that he might not desire to remove from the floor of a cavity, and that this treatment rendered teeth less liable to shocks from thermal change after they were filled. There has been much discussion as to whether any softened dentine should be left in a cavity or not, and some of the most advanced dentists of the modern school insist on its complete removal, no matter whether this exposes the pulp or not. The writer finds, as the result of twenty years' observation, that the drastic removal of the whole of the softened dentine from the floors of cavities would lead to pulp exposure in the majority of cases, and as this would necessarily entail pulp destruction, pulp removal, and root filling, with all

its many disadvantages, he still continues to practise a method that is, in his hands, a much simpler and equally good, if not better, procedure. That is to thoroughly dry up, harden, and presumably sterilise the soft floor, and then fill the tooth. Failures may occur through errors of judgment or from the the peculiarity of the case. But failures occur from the same causes in destroying and removing pulps, and filling or attempting to fill root canals. There is another little point in the preparatory treatment of all cavities, whether they contain soft dentine or not, and that is that if a cavity is properly prepared for a filling, and then temporarily filled with gutta-percha, it is found that the cavity is much more sensitive on the removal of the gutta-percha. This has led many men to suppose that gutta-percha causes sensitiveness of dentine. It is the writer's opinion that this increased sensitiveness is merely due to the increased irritability that all sensitive tissue shows after it has been lacerated or cut. If the precaution is taken to seal up a dressing of tannin paste, or creosote, or carbolic acid, &c., in the cavity by means of the gutta-percha, a decrease rather than an increase of sensibility will be noticed. The lacerated dentine is thus soothed or cauterised, instead of being allowed to rebel against the cutting. The rapidity with which a fairly thick layer of soft

dentine may be completely dried up and hardened varies considerably in different cases. Sometimes an application of twenty-four hours is sufficient, sometimes a much longer time is needed. If the desired result is not obtained, the application should be repeated, and so on, until a hard floor is produced. The thickness of the floor must be considered, for it is no use attempting this method when the soft floor is so thin that the pulp is practically exposed, and a pulp that has once been irritated may fail to completely recover, no matter how thick the floor may be. A pulp that is well covered with soft dentine, and has only become sensitive to heat and cold or has only ached for a few minutes owing to pressure of food in mastication, will often give no further trouble, but a pulp that has ached badly is always a doubtful case if its preservation is attempted.

The following case may be mentioned as an illustration of the value of treating soft dentine.

In the year 1894 the writer discovered two large cavities in the mesial approximal surfaces of the two upper centrals in the mouth of a schoolgirl, aged about fifteen years. Each of these cavities contained a mass of thoroughly softened dentine, the complete removal of which would probably have exposed the pulps. The cavities were sufficiently excavated to admit of temporary fillings

and the tannin paste was sealed up in them with temporary gutta-percha. The patient was going away to a boarding-school the next day, and was instructed to present herself again on her return home for the holidays, which she did; the teeth were then filled with hard gutta-percha, and the following year with gold. The thinness of the labial walls rendered it impossible to remove the whole of the hardened but discoloured dentine, and consequently the appearance of these teeth was not all that could be desired. For this reason, and because the enamel at the cutting edge of one of the teeth had become chipped in mastication, the gold fillings were removed in 1901, and the discoloration removed with pyrozone. During the removal of the gold, part of the labial wall of the tooth that had been chipped at the cutting edge broke away, and this tooth was filled with white cement. The other one was refilled with gold. At the present time, November 1903, the white cement filling has just been replaced with a porcelain inlay. As the result of this treatment of softened dentine the patient has two live teeth that have been perfectly comfortable from the time they were first treated, and no decay has taken place either underneath the fillings or at the margins. A complete removal of the decayed dentine would doubtless have exposed the pulps,

and necessitated their destruction; and even if, as the result of removing the pulps under pressure anæsthesia and a perfect filling of the roots, these teeth had remained in as comfortable, useful, and entirely satisfactory condition as they are in to-day, the writer submits that any dentist would prefer to have the two live teeth rather than two pulpless ones in his own mouth. The result obtained in this case was expected, and is in accordance with the results which will usually follow an intelligent application of the method.

Exposed Pulp.—If a carious tooth is left unfilled, sooner or later the decay progresses until the pulp chamber is encroached upon, and a portion of the pulp becomes exposed. In these cases, and also in cases of non-exposure where the pulp has become inflamed (this is shown by the amount of pain suffered), it is usually necessary to destroy the pulp. Many cases of successful pulp capping may be quoted—the writer has had two exposed pulps successfully capped in his own mouth, the last one being done sixteen years ago—but the proportion of failures to successes is so great that, as a general method of practice, it is hardly wise to attempt conservative treatment. It is as a rule (except perhaps for young patients with strong teeth and robust constitutions) preferable to waste no time

and run no risks of future annoyance, but at once to anæsthetise or destroy the pulp and remove it. When admissible, it is preferable to completely anæsthetise the pulp, and remove it painlessly, rather than destroy it with arsenic.

This is what is known as pressure anæsthesia. A solution of cocaine is applied to the exposure by means of a small ball of absorbent cotton-wool; the cavity is then filled with a piece of unvulcanised rubber rolled up into a ball, and gentle pressure is applied to the rubber by means of a broad-faced plugger or ball-ended burnisher. At first the pressure must be very gentle to avoid causing pain; in about a minute it may be gradually increased (reducing it if it hurts the patient), and in about two minutes considerable pressure may be made without giving pain, it may then be continued for about another minute, when it will generally be found that a fine probe can be passed to the apex of the root painlessly. As soon as this can be done the pulp should be extracted. Cocaine has been used in aqueous solution, in chloroform, in alcohol, and in a mixture of alcohol and formalin. The writer uses cocaine and formalin. He places a few drops of formalin on a glass slab, and adds sufficient cocaine to produce a saturated or slightly super-saturated solution. It does not seem to matter how minute the

pulp exposure is, so long as it is an exposure. This method usually takes from three to five minutes to completely anæsthetise a pulp, but is not always successful. It is, however, successful in a sufficient number of cases to make it a most useful method, and if it fails not much time has been wasted in trying it. Molars, however, seem to resist the treatment much more than incisors, canines, or bicuspids, and the writer having tried it in a few molars with poor success, has confined himself to the other teeth. It has been stated that inflamed pulps resist this treatment in a marked degree, just as they resist the application of arsenic. Cocaine solutions, or any of the mixtures used for pressure anæsthesia, have been injected into pulps with a hypodermic syringe. The sharp point of the needle is ground off, the end is placed on the point of exposure, the cavity around the needle is packed full of unvulcanised rubber, and the piston is slowly and gradually depressed, stopping for a short time if pain is caused, and increasing the force as the pulp becomes obtunded. The writer has no experience of this method, but it is alluded to by Mr. W. S. Holford (*British Dental Journal*, June 1903) as being particularly applicable to accidentally fractured teeth where no cavity of decay exists. Mr. Holford cuts the needle short, so that only

one-sixteenth of an inch projects beyond a small shoulder, on which is placed a small piece of unvulcanised rubber. The end of the needle is then placed in the exposure (first having obtunded the exposed part by laying a small crystal of cocaine and eucaine on it, and allowing them to be dissolved in the moisture or exudation of the pulp.

The removal of a pulp after pressure anæsthesia is generally followed by profuse hæmorrhage. This is sometimes troublesome, and can be entirely avoided by discarding the pulp extractor and substituting the Evans root-canal drier. If the bulb of this instrument is made very hot, the insertion of the wire completely and immediately burns up and carbonises the pulp; in some cases it will come out sticking to the wire. This causes no pain, and is a very safe and thorough means of removing pulps in all cases. Care should be taken to pass the wire up the canal before heating it, so as to be assured it will readily pass right up to the apex *and not beyond it.* Several sizes of the silver points or wires should be at hand in order that a suitable one may be selected; if necessary the wire can be easily reduced in size with a fine cut file. Nervocidin (an alkaloid obtained from the bark of the gasu-basu, an East Indian plant) has been recommended as a safe and satisfactory drug for anæsthet-

ising pulps, and obtunding sensitive dentine. It is sealed up in the cavity for about twenty-four hours. This local anæsthetic has only recently been procurable in England, and the writer has not as yet had sufficient experience with it to justify him in expressing an opinion as to its general usefulness. It so far promises well, but its application has often caused pain in the few cases in which he has used it.

The general method of destroying pulps is by means of a minute application of arsenic. For purposes of convenient application, as well as for reducing pain that arsenic often causes, it is usually applied in the form of a paste. It might be presumed that a paste containing drugs for the prevention of pain should be applied in a sufficiently large quantity to effect this purpose. A minute quantity of arsenic is sufficient to destroy a pulp if it is amenable to arsenical destruction, and a large quantity of arsenic will usually be deleterious. But an equally minute quantity of creosote, or sulphate of morphia, or cocaine, or whatever may be used in connection with the arsenic, can have no effect in preventing or reducing pain. If a small quantity of arsenic is mixed up with a relatively large quantity of other ingredients in a more or less liquid state, there is every risk of some of the mixture being forced out on to the

gum by the temporary filling that is used to seal up the dressing. This will (owing to the presence of arsenic) irritate the gum. In some cases the peridental membrane will become so irritated owing to exudation of the paste or mixture at the gum margin that extraction of the tooth has to be resorted to, and cases may occur in which necrosis of the alveolar process will be produced. It is therefore advisable to place a very small quantity of a stiff arsenical paste on the exposure with a probe, and then to place on this a pellet of cotton-wool saturated with such drugs as may be selected to prevent pain. There is a great prejudice against sealing up an arsenical dressing with cotton-wool saturated with mastic or sandarach varnish. If there is an intervening pellet of wool saturated with medicaments, or only damped with water, between the arsenic and the wool and mastic, there is not much likelihood of the varnish flowing around the arsenic and preventing its action ; nor is there much probability of the wool and varnish being displaced in a reasonable time in approximal cavities, for the next tooth will help to keep it in place. If the adjacent tooth is missing a silk ligature may be tied around the tooth and varnished wool. The chance of the arsenic being squeezed out of the cavity during the insertion of the wool is remote, and pressure

during its insertion is reduced to a minimum. Of course a fairly thick varnish should be used. The writer sees no advantage in the employment of metal caps for covering arsenical applications, and preventing pressure; this is more trouble than it is worth, and it is easy to seal up the arsenic without pressure. Temporary gutta-percha should always be very carefully used, and packed to place with lateral pressure; this is the material of all others that is likely, not only to squeeze out some of the arsenic, but also to produce pressure on the pulp. Many operators use Fletcher's artificial dentine (oxysulphate of zinc) in these cases. The writer prefers a thin mix of a slow-setting oxyphosphate cement, and presses it to place with instruments dipped in vaseline. It should be sufficiently soft to almost flow to place, so that absolutely no pressure is exerted on the pulp. These thinly mixed oxyphosphates set sufficiently hard for all practical purposes, and are not difficult to remove. An oxyphosphate or a wool and varnish covering of an arsenical application is therefore recommended, with a distinct preference for the oxyphosphate in many cases. In cases where the direct application of arsenic to the pulp is difficult, or very painful, a small hole may be drilled in the dentine at some convenient place

remote from the pulp; a small piece of arsenical paste should then be placed in the bottom of the hole, which should be filled up with temporary gutta-percha. This leaves the rest of the cavity free for the use of obtundents, and precludes the possibility of the arsenic becoming displaced and getting on to the gum. It will—even in favourable circumstances—take about a fortnight for the effect of the arsenic to travel through the dentine to the pulp and completely destroy it in these cases.

It is generally considered that arsenic has no effect on inflamed pulps, and that inflammation should always be reduced before it is applied. It is certainly good practice to relieve an aching tooth as promptly as possible by appropriate remedies, and then at the next sitting to apply the arsenic; but there are cases when a tooth resists all the usual soothing applications, and the application of arsenic is followed—after usually a period of increased pain—by relief. The writer has often found that the relief has occurred long before the pulp is destroyed or even rendered insensitive to touch. It is considered that the efficacy, as well as the painlessness, of an arsenical application is greatly increased by making a free exposure. The writer has only in exceptional cases been able to

freely expose a pulp without causing the patient great pain, even with the lightest manipulation; and unless the patient is suffering severe pain at the time, he finds it inadvisable to attempt it. When, however, an arsenical application causes great pain, and the case admits of it, a free opening may be made with an engine-bur, and if, as frequently happens, this is followed by an immediate and complete relief, owing first of all to the hæmorrhage, and secondly to some soothing application which may also contain some arsenic, the patient will forgive the dentist, and bless him for his thoroughness. One of the writer's friends, who practises abroad, once informed him that he had no trouble after applying arsenic, his method being to always freely expose a pulp, and then give it a good cut with an excavator to make it bleed well. This is a heroic proceeding that the writer has never had the hardihood to attempt.

The resistance of pulps to the action of arsenic varies considerably, and this by no means entirely depends on inflammation, so far as can be judged by the presence or absence of pain before making the application. It is very often an extremely difficult matter to succeed in destroying a pulp with arsenic in anything like a reasonable time. Time after time a patient will return; the

tooth will be re-dressed, and although the superficial sensitiveness may be sufficiently obtunded to admit of the freest exposure, deeper exploration produces pain, and eventually the arsenical dressing is removed, the tooth temporarily filled, and the patient told to return in a few months or earlier if painful symptoms or uneasiness develop. If a large quantity of arsenic is used, and the dressing frequently repeated, or left in the tooth for a long time, in all probability severe peridental inflammation of an almost uncontrollable character will be set up, and extraction will usually follow. In the text-books allusion is made to the *occasional* resistance of a pulp to the action of arsenic, but that it is of frequent occurrence accords with the experience of many dentists. In the *Journal of the British Dental Association* for April 1894, an article by Mr. Arthur King appeared on this subject in which the by no means infrequent resistance of the pulp to arsenic is alluded to. The use of what are known as mummifying pastes has great value in such cases. It is a rare thing for a pulp to live after an application of arsenic, and it should therefore never be calculated on. It is the time that the pulp takes to die that is frequently so troublesome, and especially so if it decomposes and an abscess forms before the patient returns. The appli-

cation of mummifying paste will probably prevent the decomposition of the pulp for a considerable time, and whatever may be said against its use as an alternative to pulp removal and root-filling, there can be no doubt of its value in these cases as a temporary expedient. A paste containing formaldehyde in some form is especially valuable, for formaldehyde is in itself a pulp destroyer, and it will no doubt in many cases cause the pulp to die more rapidly. Formaldehyde applied to an exposed or nearly exposed pulp will cause considerable pain, but the writer has so far had no cases of pain caused by this mummifying paste after a pulp has been treated with arsenic, and has ceased to give pain. A free exposure should be made, and as much of the bulbous portion of the pulp removed as can be done without causing pain. Paraform, thymol, and oil of cloves, made into a paste with oxide of zinc, is very efficacious. When a pulp is *completely* dead—a condition readily ascertained by delicately inserting a fine Donaldson bristle, or a fine Swiss broach, down the canals—it is necessary to remove it if possible. The bulbous portion in the crown may be easily cut out with engine-burs, and the prolongations down the roots extracted by means of the ordinary "nerve extractors" if the canals are fairly large, and with

the fine No. 5 Donaldson canal cleanser if they are small, scraping the dead pulp out bit by bit if necessary. The value of the Evans root-canal drier instead of the more usually employed instruments has been alluded to, and will be found particularly valuable if the canals are difficult to "get at." In many cases it can be successfully, used with far less cutting away of a tooth than would be necessary if the pulp extractors or canal cleansers were used in posterior cavities in molars.

The careful and thorough removal of the pulp is often difficult and sometimes impossible. A good deal of trouble is sometimes set up by forcing the instrument through the apex, and in very fine canals, especially if the operator desires to be thorough, this may easily happen. It is far better to make every reasonable effort to remove the whole of a pulp, and then to trust to the careful working down of mummifying paste, than to spend a great deal of time in making almost superhuman efforts which after all may not be crowned with success. The operator should be guided by circumstances, and all the "pros and cons" should be considered. An attempt to thoroughly remove the pulp from a second or even a first lower molar for instance—particularly if the cavity of decay is on the distal surface—often demands such severe cutting

up of the tooth as to thoroughly weaken it, and even then the anterior root will present great difficulty in many cases. A pulpless tooth is a brittle tooth, and demands a goodly amount of strength if it is not to afterwards break down. To greatly reduce its strength in order to reach these canals may necessitate a gold crown. The success of mummifying pastes is so great that their use is certainly justified in these cases. The writer has no wish to lay down rules in these or similar cases; he merely wishes to suggest that a broad-minded method of practice, based on the selection of methods that appear most appropriate to the particular case in hand, is most likely to do "the greatest good to the greatest number." "Let the treatment fit the case," rather than attempt to "make the case fit the treatment."

Treatment of Teeth in which Decomposition of the Pulp has Taken Place.—When a pulp has died "a natural death" it will usually be found in a putrid condition. If it has been long dead the roots will be filled with foul débris, in a more or less liquefied state, and owing to the irritation caused by the absorption of the products of putrefaction, the peridental membrane will be usually in a more or less inflamed and diseased condition.

The treatment consists in carefully removing the

contents of the canals, being very careful to avoid forcing anything through the apices; in treating the canals with some powerful germicide, and either at once, or at some subsequent sitting, filling the roots, first having, if necessary, sufficiently reduced any active inflammation which might interfere with the operation. Irritation and inflammation of the peridental membrane are caused and kept up by a septic condition of the root-canals, and by removing the cause nature is often enabled to effect a cure, but when there is much degeneration of the membrane, and when pus has formed, producing alveolar abscess, the removal of the cause is not always efficacious, and it becomes necessary to cauterise or stimulate the parts to healthy action. This can usually be accomplished by pumping the remedy through the apex, using an old "nerve extractor" (perfectly clean) wrapped round with a few fibres of cotton-wool. Some operators use a syringe for this purpose, but unless great care is taken the liquid may be forced through the apex with too great pressure, and (unless there is a fistulous opening) considerable pain may be caused. It is, of course, necessary for the canal to be perfectly freed from all débris before an attempt is made to force anything through the apex. Carbolic acid (full strength) is generally efficient for this purpose. Creosote is equally useful, and is preferred by some.

In obstinate cases sulphuric acid (twenty to fifty per cent.) may be used. When everything else has failed, the writer has often had happy results with nitrate of silver (full strength)—but this may cause disagreeable discoloration of the teeth. When a fistulous opening exists, the remedy should if possible be so forced through the apex of the root that it exudes from the opening in the gum. This can generally be readily accomplished, particularly if the canal is filled with the remedy, the cavity of decay tightly filled with unvulcanised rubber, and pressure made on the rubber. Should a fistulous opening remain unclosed for some time after the roots are filled, the remedy may be applied to the diseased part through this opening, enlarging it if necessary. Fusing nitrate of silver into a little ball at the end of a platinum probe or fine wire is a convenient means of applying this remedy in these cases. In cases of blind abscess, an opening may be made to the end of the root by cutting or drilling through the outer alveolar plate. This is often a ready and efficacious method of treatment in these cases, but is too heroic a proceeding to be recommended as a general practice, owing to its usually causing great pain unless gas or ether is administered. In some cases the amputation of the ends of roots is recommended, and in others a good

deal of the diseased tissue may be scraped away from the roots through an outer opening. The writer has never amputated the end of a root, and having had the two roots of a lower molar well scraped in his own mouth after instrumental enlargement of a fistulous opening, he hesitates to subject a patient to the same treatment, and the suggestion of a performance of these operations under ether has the disadvantage of being objected to by many patients who, strange to say, would not object to extractions under this general anæsthetic.

Many operators think it is unnecessary, and even inadvisable, to postpone the filling of roots, providing there is no flow of either blood or pus down them, or the presence of any active state of inflammation that will interfere with this operation. They trust to mechanical cleansing, and to the use during and immediately after this of some powerful germicide. They consider the result to be quite as good, if not better, than if the filling operation was postponed. Others, on the contrary, hold that the dentine has absorbed products of putrefaction, and can only be sterilised by thoroughly soaking it with a germicide, and that this cannot be accomplished at one sitting. They are aware that the sealing of the apex by root-filling, if thoroughly accomplished, will prevent the passage of anything through it, and

that a barrier is thus set up which may prevent any further trouble. Some, amongst whom the writer is included, have not much faith in their own ability, or in the ability of others, to fill all root-canals in such a manner that the filling always extends to and never beyond the apex, and with materials that can be packed tight, and will *remain* tight, without shrinkage or absorption. The experiments made by Dr. Kirk to prove whether the coagulation of albumen produced by certain remedies (such as chloride of zinc) prevents their absorption, certainly show that the dentine and cementum are more permeable than is generally supposed (*Dental Cosmos*, March 1894), giving good grounds for the fear, always felt by the present writer, that sooner or later (granting the apex is perfectly sealed) products of putrefaction absorbed by the dentine, and allowed to remain there, will find their way to and irritate the peridental membrane through the solid structure of the tooth.

Immediate Root-Filling, which should properly be termed the immediate treatment of roots, or the treatment of roots at one sitting, can only be successfully and scientifically practised if the whole of the dentine of the root is sterilised at the one sitting, or if the apex is sealed and the root is then filled with an antiseptic that will in due course become

absorbed by and thoroughly penetrate the dentine. To accurately seal an apex, and then leave the rest of the canal free, is very difficult in many cases. An excellent method, if immediate sterilisation is attempted, is to promote the absorption of the germicide by means of heat. A root that is dried as perfectly as possible is in the best condition for rapidly absorbing a germicide, and the vaporisation of a germicide in the root will probably cause it to penetrate more rapidly and thoroughly. A paste or mixture of europhen and carbolic acid has been recommended for this purpose by Dr. K. J. Schumann, in the "Items of Interest," page 256, 1900 volume. Europhen is a substitute for iodoform (having similar properties), and is free from the disagreeable odour of the latter. The Evans root-canal drier can be satisfactorily used for drying the canal and vaporising the medicament. The writer places a little carbolic acid, or creosote, on a glass slab, and by means of a spatula works europhen into it until a syrupy or treacle-like solution is produced, sufficiently thick and viscid to adhere readily to the Swiss broaches, or fine steel bristles, used for placing it in the canals. The immediate method adopted by the writer in septic roots is to carefully open up the cavity, and expose the orifice of the canal, taking care that

the bur does not make sufficient pressure at the orifice to act somewhat as a piston, and force any of the putrid contents through the apex. The europhen paste is then delicately inserted about a third of the way into the canal, and vaporised as much as possible with the root drier. More paste is then inserted half-way down the canal, and vaporised. Then a third application goes three-quarters to the apex, and finally the paste is carried to the apex, and the root drier follows it right to the end of the root. It will be seen that no attempt is made to clean out the canal in the ordinary way. The object of this is to cause a penetrating vapour to go ahead of the instrument, and this, aided by that most potent germicide, heat, will probably prevent the possibility of forcing septic matter through the apex. There is also less chance of forcing anything through the apex if a fine smooth bristle or wire is used, than with the finest barbed canal cleansers or the finest broach wound round with cotton-wool. After the apex has been reached with the root drier the canal cleanser may be used if thought good, and the root well scraped and filled. The *insertion* of the hot root drier causes no pain, but as soon as the root becomes thoroughly hot the patient will feel a little pain, and should be instructed to give notice

of it. It disappears on the withdrawal of the instrument. At each application of the root drier it should be kept in the canal until sensation is felt, so that the germicide is vaporised as much as possible, and the sterilisation by heat is as complete as possible. The treatment, carefully carried out in this way, will take about half-an-hour. The time can no doubt be reduced by reaching the apex more rapidly; but just how far it is safe to hurry this is a question of individual experience. The practical test of thorough root sterilisation is to leave the canal unfilled, and tightly seal up the cavity of decay with temporary gutta-percha for from three days to a week. If the products of putrefaction absorbed by the dentine have not been completely or sufficiently neutralised, they will be given up by the dentine, find their way into the canal, and out at the apex, causing peridental inflammation and pain. It will be well for any one who contemplates immediate treatment to test this method in this way, and to adopt it as a regular practice only when he has by the above means—or, better still, by laboratory experiment — assured himself of its efficacy. Those operators who are able to thoroughly ream out and greatly enlarge canals in all cases, remove a good deal of infected dentine, and this is a great help; but just in proportion as

a canal wants reaming out, so the difficulties of doing it are increased, and even when reaming is resorted to, it is safer to first have the root as sterilised as possible, in order to prevent trouble in the event of any dentine that is removed by the reamer being forced through the apex. It is considered important for all instruments used for root treatment to be surgically clean, but to carefully sterilise an instrument, and then immediately foul it by inserting it into a septic root, seems to be taking an unnecessary precaution. Clean cases demand surgically clean instruments. For dirty cases one need not be so extremely particular. The Evans root drier is, however, always aseptic, owing to the heat to which it is subjected. It is generally considered unnecessary to do anything more than superficially sterilise a root canal, if a live pulp, or one that has been destroyed by arsenic, has been removed. The dentine, however, contains a certain amount of organic, and consequently decomposable matter, and unless an attempt is made to sterilise the dentine in these cases, it is certain that every possible precaution has not been taken.

The Dressing Method.—This name has been given to repeated applications of germicides to root canals before filling them. In this case the canals are

cleansed thoroughly, or as well as possible; they are then flooded with the selected medicament, and the tooth is temporarily filled. In a few days the temporary filling is removed, and the canals redressed, until all odour of putrefaction has disappeared. In these cases the use of remedies that are very persistent in their action is advantageous, and this property is possessed in a marked degree by some of the essential oils.

In the *Dental Cosmos* of April 1889 a very important table is published, giving the value of various essential oils, and some other well-known remedies, as germicides and antiseptics in the treatment of root canals. These tables, drawn up by Dr. Black from his own experiments, give great value to the oils of cassia and cinnamon, 1 in 4000 of the former, and 1 in 2000 of the latter proving effective. Since that time the writer has made large use of the oil of cassia in treating septic roots, with thoroughly satisfactory results. It has recently been stated that, owing to the increased demand for oil of cassia, it is not nearly so strong as it used to be, but it is still the most powerful germicide amongst the essential oils, being now a little more powerful than cinnamon.

Dr. Harlan on Essential Oils.—In the *Dental Cosmos*, October 1889, a very interesting paper

appears on certain of the essential oils, by Dr. Harlan, in which he alludes to the valuable properties of the oils of cassia, cinnamon, &c., from which the following is taken :—

"The most remarkable property possessed by the essential oils is one that has heretofore escaped general attention. The writer first pointed this out in a paper read before the Odontological Society of Great Britain in 1887. Essential oils of the varieties mentioned above, and a few others not necessary here to particularise, when introduced into a cavity of a living tooth and sealed therein, slowly deposit vaporisable camphors, which are potent antiseptics. These camphors are very sparingly soluble in water, and in consequence of this are not easily dissipated by moisture should the cavity be not hermetically sealed. The same vaporisable camphors are likewise deposited when the oils are sealed within the roots of a tooth. It is on this account that they so readily and certainly disinfect polluted dentine. The writer (Dr. Harlan) wishes it distinctly understood that he believes that the dentine of a pulpless tooth — long dead, and in which the pulp or other vegetable or animal matter has decomposed—must be disinfected in order to prevent a gradual deterioration of the cementum and pericementum. This is a necessity to insure a

feeling of comfort in a pulpless tooth after the root and crown have been filled. Many pulpless teeth filled and treated by purely mechanical methods, without respect to the complete disinfection of the dentine, are a permanent source of discomfort to their possessors.

"Of the many agents and processes for the disinfection of the dentine of a pulpless tooth, none possess so few disadvantages in the handling as the essential oils. They do not act with the instantaneous rapidity that some forms of mercury do, or even with the rapidity of hydrogen peroxide, but their action, if slower, is more perfect and continuous. The oils do not lose their property by exposure, they do not deteriorate, and their efficacy has been established clinically as well as in laboratory experiment. To sum up their advantages in dental practice I would say:—

"1. They possess local anæsthetic properties.

"2. They are stimulants.

"3. They are non-coagulants.

"4. They are sparingly soluble in water, and on this account are not contaminated by saliva, food, or other foreign substances.

"5. They are diffusible.

"6. The camphors which are deposited, when brought in contact with the slightest quantity of

water, saliva, or blood serum, are vaporisable as soon as formed. At a temperature of about 94° F. their extreme volatility permits them to thoroughly impregnate the dentine. The camphors are disinfectants in full strength, as was shown by their deposition on the sides of tubes coated with broth in which various forms of bacteria were planted. In the ends of the tubes, where the camphors were not deposited, a vigorous growth was invariably observed.

"7. The vaporisable camphors are the agents which disinfect the so-called blind abscesses, even when the oil is not introduced into the root of a tooth further than the pulp-chamber, where it is sealed only moderately tight.

"8. The foul contents of a root canal, after being in contact with the oil of cinnamon, oil of cassia, and eugenol for two days, when planted in sterilised beef-broth failed to show any sign of life or development at the end of fourteen days. Repetition of this experiment by planting a fresh tube daily for fourteen days failed to show any sign of bacterial life."

A method of procedure (based on Dr. Harlan's) adopted by the writer for several years is, at the first sitting, to open up the tooth, clear out the bulbous portion of the pulp-chamber, place in

it a ball of cotton-wool saturated with the oil, and fill with temporary gutta-percha, making two or three small holes through the filling to the cotton-wool for the escape of the gases of putrefaction. At the second sitting, the canals are partially or wholly cleansed and the oil worked down them, taking care to avoid pumping it through the apex, as it is very irritating, and proceed as before. At the third sitting, complete the cleansing of the canals (if it has not been done at the previous sitting), place twists of cotton-wool saturated (but not dripping) with the oil loosely in them (if the canals are large enough), and complete as before, only this time make no holes in the filling. If the tooth is perfectly comfortable for three days, the roots may be filled, and the case completed.

Should any trouble arise between the third treatment and the completion of the case (which will rarely happen unless the oil has been forced through the apex), making one or more holes through the gutta-percha gives relief. This simply means that the tooth is not thoroughly sterilised, and one or two more dressings will be necessary. One great advantage of these oils is that they are more permanent or persistent in their action than many other remedies. Many germicides act while they are being applied, and for a short time afterwards,

but practically for a ten minutes' application a ten minutes' result is attained, while with these oils the action seems to continue for several days, and it is advantageous to place something in a tooth that will be working of its own accord during the time that intervenes between the sittings.

The oils of cassia and cinnamon have a tendency to sometimes discolour teeth, and it is therefore unwise to use them in incisors, for even a slight change of colour, that would be unnoticed in bicuspids and molars, is here very apparent. The oils of cloves and peppermint will therefore be preferable in front teeth, although their action is not so strong.

In the treatment of pulpless teeth there is still much to be desired, and that there is a great field here for new and improved remedies is shown by the eagerness with which dentists fly to new antiseptics and germicides. To allude to all the remedies that have been used with success would be beyond the scope of these "Notes," and it is, of course, impossible for any one man to have given a sufficiently extended trial to a tithe of the germicides that are used to warrant him in expressing an opinion respecting them.

Many experienced dentists believe that the old-fashioned creosote is quite as good, if not better,

than any of the more modern productions. It is not as powerful a germicide as some (Dr. Black's tables give 1 in 400 as being efficient), but, perhaps, combines in itself more valuable properties than any other single remedy. It is an excellent cauterant for an alveolar abscess, and if accidentally forced through the apical foramen when not needed, is less irritating than the oils of cassia and cinnamon. It has been stated (just as has been oil of cloves) to be devoid of irritating properties. This, however, is not borne out either with creosote or oil of cloves in the clinical experience of the writer. It appears to be fairly persistent in its action, and is stated to possess some local anæsthetic properties. Its odour is, however, strong, and permeates the operating room; and an odour of drugs about an operating room has a disagreeable effect on some patients. Beechwood creosote is considered the best.

In making tests in infected bouillon in order to determine the antiseptic properties of various essential oils and some other antiseptics, Dr. A. K. Peck found that 1 in 338 of carbolic acid was an efficient antiseptic; beechwood-creosote, 1 in 1280; oil of cloves, 1 in 1150; oil of peppermint, 1 in 875; Black's 1, 2, 3 (viz. 1 part oil of cassia, 2 parts carbolic acid, 3 parts oil of wintergreen) was

antiseptic in 1 in 454; eucalyptol, 1 in 116; oil of cinnamon, 1 in 2100; oil of cassia (the modern or adulterated oil), 1 in 2233. Eugenol and oil of wintergreen were found to be both useless as dental antiseptics. This still gives very high value to oil of cassia, and the high place that creosote occupies in these tests will please those who have "stuck to it through thick and thin," notwithstanding the frequency with which it has been decried. Dr. A. K. Peck's experiments were published in the *Dental Review*, August 1898.

The quality of many germicides, drugs, &c., probably varies somewhat, and this doubtless accounts for the different results obtained by different dentists.

Every dentist who gives much attention to this work probably has his favourite remedy, but success will always depend more on its application than on the remedy itself. Time, patience, care, and digital dexterity are the main requirements, and although different conditions may demand variations of treatment, the best results will always be obtained by the intelligent selection and skilful use of a few medicaments.

Before dismissing this subject it may be mentioned that the treatment suggested for immediate root-filling will apply equally well to the more

prolonged or dressing method, and that it passes to the dressing method as soon as in any case the root is filled with the paste, and the tooth is only temporarily filled. It is suggested, however, that after the careful application of heat and vaporising of medicaments, the tooth should be tightly sealed at once as a test, and the treatment only repeated if necessary.

Filling Roots.—This is a subject that must be carefully approached, for the differences of opinion that exist are many and various. Some operators go so far as to say that if the whole of the root is thoroughly sterilised it is of little or no moment whether the canals are filled or not, providing the apex is of normal size; and that as long as the orifices of the canals are sealed with the tooth filling proper, these cases will prove just as satisfactory as if the canals were filled. Others hold that all canals should be solidly filled to the apex, and that every effort should be made to enlarge fine canals sufficiently to enable this to be thoroughly done.

Many dentists (and even those who place no great faith in the *necessity* for root-filling) prefer to fill the canals with some antiseptic paste, generally in connection with cotton-wool.

The theory of solidly filling canals, mainly con-

sists in a possible or probable weeping in of the exudations of the tissues surrounding the root near the canal through the apex, and a consequent decomposing of this exudation in the canal. A solid root canal-filling is supposed to entirely prevent this, and it also prevents the far more likely, and consequently far more serious, filling up of the canal with decomposable substances, if the filling of the tooth proper fails, and the canals in consequence become exposed. There is no doubt that solid root-fillings have enabled many roots to be successfully crowned after loss of fillings from subsequent decay, that would have otherwise become so infected and decayed that extraction would have been resorted to. Theoretically and practically, therefore, root-fillings of a solid kind are useful. As against this, we have to consider the uncertainty of knowing the condition of the peridental membrane, and it is safe to presume that a peridental membrane that has once been severely damaged may at any time give trouble. It is well known that venting the canals is not only the promptest but often the only means of relieving peridental trouble, and it is also well known to those who have been long in practice that a re-treated canal will often enable a tooth to be comfortably retained. Now the venting and

re-treating of a canal depends on the removal of the root-filling; and just in proportion to the solidity of the root-filling, and the thoroughness with which it has been inserted, so will the difficulties of its removal be increased; indeed in many cases its removal is an impossibility. The writer has, on many occasions, removed root-fillings for the relief of pain, and found the canals clean and perfectly sweet. He could attribute the trouble to no imperfection in the root-filling, or to any decomposition in the canals. Venting these canals gave relief, and the teeth were afterwards satisfactorily filled as far as absence of pain or discomfort was concerned. In some cases the root-filling was of gutta-percha; in others of cotton-wool, usually smelling strongly of an antiseptic. These cases, in many instances, had been originally treated and filled by other dentists, and the patients had consulted him for relief because they were away from home, and could not consult their regular dentist. Personal experience, thus backed up by cases from the hands of others, as well as a perusal of literature on this subject from the pens of some of the most experienced and skilful treaters of teeth and fillers of roots in the world, makes one hesitate to use solid root-fillings, especially after experiences of many hours spent in removing them, and many

failures to do so. Bearing in mind that the removal of root-filling is occasionally necessary, no matter how carefully and well the case has been treated, and also bearing in mind that so many of these cases show absolutely sweet canals when only cotton-wool and an antiseptic have been used, one is forced to the conclusion that the insertion of root-fillings that are troublesome to remove, or, it may be, impossible to remove, is, generally speaking, an unwise practice. Some of the ablest dentists hold that a root should always be solidly filled; that such a thing as ever having to remove the root-filling must not be considered. If trouble occurs it must be treated from the outside, either by forcing an abscess to form and discharge through the gum, or by drilling or cutting through the alveolar process. The former method is uncertain, and subjects the patient to days of suffering. The latter brings dentistry within the region of oral surgery, and no matter how desirable this may be from a dentist's point of view, it is neither desired nor appreciated by the public. The true compromise between the unfilled and the solidly filled canal consists in the use of cotton-wool and an antiseptic paste. It has been pointed out by Dr. Flagg, that raw cotton (not the absorbent kind) is practically impervious to moisture if care-

fully packed into a root-canal, and it can be readily removed. Mr. Mansell has a record of seventeen or eighteen years' successful use of a paste of iodoform and oil of cinnamon. He works the paste into the canals with fine broaches, and then packs down a tent of cotton-wool. The paste penetrates the dentine, and renders it thoroughly antiseptic. He does not find that this paste is irritating if accidentally forced through the apex. He recently informed the writer that he saw no reason for exchanging it for any other process at present introduced. The possibility, if not the probability, of some of a paste root-filling going through the apex must be always considered, and a paste that is as antiseptic as possible and completely non-irritating should be chosen. The writer intensely dislikes the odour of iodoform in his operating room—there are several substitutes for iodoform which have no disagreeable odour, and many other kinds of pastes that may be used. All that is needed is a penetrating, non-irritating, and lasting antiseptic, or mixture of antiseptics, that can be made into a paste with some suitable medium for ease and certainty of introduction, and stability.

A test of many of the most popular solid root-fillings that are used proves that only the oxychloride

of zinc makes a non-permeable one. Its use in the form of the usual oxychloride cements is, however, difficult. Its removal is usually impossible, and as some fluid usually goes through the apex, it causes considerable pain for some time after insertion. The prevention of this by sealing the apex with a tiny piece of gutta-percha or a small ball of cotton-wool is excellent in theory, but extremely hard to properly carry out in practice, except in fairly large canals that are easy of access, or in the practices of those who are particularly skilled in reaming out root canals. The writer has had the canals of a first lower molar in his own mouth (two canals in the anterior root) so reamed out that several strips of *cohesive* gold were accurately carried down each canal, and condensed with a hand mallet. Each strip was packed and condensed just as in an ordinary gold filling, but this is quite exceptional practice, and outside the range of all ordinary and no doubt equally useful methods.

It has been mentioned that a gutta-percha filling will not leak against the cavity walls if the tooth is first varnished with resin dissolved in chloroform, and a method of overcoming the shrinkage or permeability of gutta-percha was suggested by Dr. Goble, in the "Items of Interest," April 1894. Dr. Goble dissolves about equal parts of rosin and

gutta-percha in chloroform, fills the canal with it, and then introduces and presses down a gutta-percha point. He claims that this produces a moisture-tight and gas-tight filling, and that the rosin is in itself an antiseptic. In using gutta-percha points two things are of importance. One is to test the size of the apical foramen by carefully inserting Swiss broaches with the sharp points cut off, until one is found that will distinctly "jam" against the apex without penetration, and then to cut off the end of the gutta-percha point accordingly. The other is to insert the gutta-percha point with as little pressure as possible. The writer filled several roots in extracted teeth by first filling them with chloro-percha, and then forcing in a gutta-percha point. He was alarmed at the quantity of chloro-percha that was forced through the apex in nearly every case. A digression may be made for a moment to point out the ease with which any medicament with which a canal is treated may be forced through the apex by a forcible or hurried filling of the cavity of decay with temporary gutta-percha. A root should never be solidly filled unless it has been thoroughly scraped out, for fear of forcing some of the débris through the apex, and setting up inflammation by either septic or mechanical irritation. It is also

suggested that a non-solid root-filling should be packed sufficiently down a root to admit of the orifice being well sealed, and the seal (either a white cement or gutta-percha) extended sufficiently into the root to preserve it if the crown of the tooth is subsequently destroyed or broken down. Canals can generally be sufficiently enlarged to admit of their being filled by scraping them with the Donaldson canal cleansers, and these are far safer instruments to use than drills or reamers.

Very fine canals that cannot be thoroughly scraped out may be sterilised as far as possible, and left unfilled. The buccal roots of upper molars, and the anterior roots of lower molars, usually present the greatest difficulties in this respect. Dr Callaghan's method of applying a 50 per cent. aqueous solution of sulphuric acid, and working it down fine roots with suitable probes (Dr. Flagg advises iridium-platinum and platinum-gold probes) enables many apparently inaccessible canals to be cleaned out and filled ("Items of Interest," April 1894).

It is difficult to apply sulphuric acid directly to the roots of teeth—especially upper roots. If a little cotton-wool is twisted round the probe, the cotton is almost immediately destroyed by the acid, and any method which causes a flooding of the

main cavity with the acid is undesirable. The use of *aqua regia* (nitro-hydrochloric acid) has been recommended in preference to sulphuric acid for this reason by Dr. F. T. Hayes (*Dental Cosmos*, December 1900). *Aqua regia* can be carried to a cavity by means of cotton-wool wrapped round a fine probe, for it does not destroy the wool, and consequently it can be more easily worked into a canal. It appears to act quite as well as sulphuric acid. These acids are potent germicides, and one may be tempted to use them for this purpose. Their use, followed by the neutralising effect of bicarbonate of soda, has been recommended as a ready and efficient means of cleaning all root canals. It must, however, be borne in mind that they are very irritating, and that a thorough cleansing of all kinds and sizes of canals by their means is likely to cause considerable irritation in many cases. Used for the opening up and penetration of very fine canals they are often indispensable, and they have also great value in enabling a closed apex to be often opened without resorting to the dangerous drill. In cases of blind abscess, when the finest steel bristle cannot be made to pass through the foramen, the use of these acids in connection with the bristles will often enable the apex to be opened and the pus to escape, to the great

relief of the patient, and the satisfaction of the dentist.

If much degeneration of the peridental membrane has taken place, the use of germicides, and cauterants and the most thorough cleansing and careful root-filling will fail to restore the parts to health. An improvement in the conditions is all that can be hoped for. It is astonishing, however, how long a badly diseased tooth may be comfortably and usefully retained in the mouth owing to the above treatment, although sooner or later it will be lost.

Dr. Thomas, of Philadelphia, who practises extraction as a speciality, finds that sooner or later all "so-called dead teeth" fall a prey to the forceps, but that careful treatment postpones extraction in the majority of cases for a long time. Much depends on the constitution of the patient. The exact condition of the affected parts cannot be ascertained while the tooth is in the mouth. All that can be done is simply to apply remedies, and if the tooth readily becomes comfortable and can be satisfactorily used for mastication, a cure may be considered to be effected. Those dentists who treat and fill all pulpless teeth that appear to be worth saving, find that a very great majority are by means of the treatment usually retained for a long time, and

although it is impossible to accurately gauge the life of any individual pulpless tooth, or to hope every case will respond to treatment, the success and practical value of root treatment and filling is beyond question.

APPENDIX

NOTE BY PROFESSOR SMITHELLS

ON DETERMINING THE SPECIFIC GRAVITY OF GOLD FILLINGS

THE YORKSHIRE COLLEGE, LEEDS.

WE have found it impossible to make any accurate and useful determinations of the "dental" specific gravity of your plugs by simply weighing in air and then in water. The plugs are more or less porous, and as the water gradually enters the pores the apparent weight alters. After a number of different trials, we settled on the following method, which has given satisfactory results:—

The fillings were first made impenetrable to water by heating in vaseline to 100° C. for ten minutes. When the vaseline had cooled to the temperature of the room, the fillings were removed and thoroughly polished with fine linen. The *volume* of each impenetrable filling was calculated from the difference

between its weight in air and its apparent weight in water. The vaseline was removed from the fillings by treatment with petroleum ether in a Soxhlet apparatus for three hours. After removal of the petroleum ether by heating to 100° C., the fillings were weighed. Having thus measured the volume of the filling and determined its weight, we get at once the "dental" specific gravity.

ARTHUR SMITHELLS.

December 1903.

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THE END

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